Retrospective analysis of blunt force trauma associated with fatal road traffic accidents in Cape Town (South Africa) over a two-year period.

by

T. A Tiffany Majero

(MJRTIN002)

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Supervisors: Calvin Mole

Department of Pathology

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ABSTRACT

Road transportation systems are a global developmental achievement. However, with them comes increased morbidity and mortality rates in the form of road traffic accidents. In South Africa, there is a need to characterize road traffic accidents and the injuries associated with them, to determine the preventative mechanisms required to reduce their morbidity and mortality rates. A brief review of fatal road traffic accidents from a global perspective is presented, highlighting the current literature surrounding the prevalence, demographics and blunt force trauma injuries associated with road traffic accidents in South Africa. There is limited research regarding the prevalence and characteristics of road traffic accidents. The objective of this study was to determine the prevalence of fatal road traffic accidents, necessitating the need for research, particularly at the regional level.

A retrospective analysis was therefore conducted of all fatal road traffic accident related deaths autopsied at Salt River Mortuary (which services the West Metropole region of Cape Town, South Africa) from January 1st, 2013 to December 31st, 2014. The mean prevalence of road traffic accidents for the reviewed period was 15.9 / 100 000 population. The majority of road traffic accident victims were males who fell in the age group of 30 – 49 years. Over the two-year period, the majority of road traffic accident victims were pedestrians with elevated blood alcohol concentration levels.

The head and facial regions of victims commonly exhibited external injuries, while the majority of fractures and organ injury were seen in the head and chest regions. There are limited studies which have investigated the blunt force trauma injuries associated with road traffic accidents in South Africa, and there is a need for further research. Interventions are of paramount importance to decrease fatal road traffic accidents, particularly amongst pedestrians as a road user. This study presents recent data on road traffic accidents for the West Metropole region of Cape Town (South Africa).

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CHAPTER ONE:
Literature Review

1.1 Introduction

Road transportation systems are a global developmental achievement. However, their establishment contributes to an increase in global morbidity and mortality rates. This review will discuss the global epidemiology of road traffic accidents (RTAs) as well as critically evaluate the literature surrounding RTAs in South Africa,

1.2 Definition of a road traffic accident

Collecting data on RTAs is important to monitor their contribution to morbidity and mortality rates. In addition to this RTA data assists in assessing if road safety mechanisms are required and if those that have been implemented are working. However, there is no universal definition of an RTA [1]. As a result, definitions vary from country to country which makes a comparative analysis of global RTA mortality and morbidity rates challenging [1]. Peden *et al*. [1] reports that since 2010, 100 countries now use the 30-day definition of RTAs. This means that police will follow up on the outcome of an RTA if death occurs within 30 days of the accident [1]. The death is recorded as an RTA fatality if it occurs within 30 days of the accident. The lack of follow up by police and the exclusion of deaths, which occur after 30 days facilitates a statistical under representation of the true extent of RTA fatalities.

There are a number of definitions for accidents involving transport related vehicles hierarchically organised according to a number of transport modes. These include

transportation related fatalities (these include all transport related fatalities from aircraft ships to motor vehicle occupants to cyclists to skate boarders to pedestrians), road traffic fatalities (these include all road users, from pedestrians to cyclists to bus users to skate boarders and motor vehicle related fatalities which only involve motorised registered vehicle statistics. Previous studies [1-4], define a RTA as a collision that occurs on a road between a moving motor vehicle and an object (such as a wall, tree, building or debris), an individual(s) (such as a pedestrian, a cyclist or motorcyclist), an animal or another motor vehicle. These studies did not include cases where the injury occurred on the road but did not involve a collision (e.g. a person falling out of a moving vehicle, a person slipping or falling on the road) or a stationary vehicle (e.g. a person sustaining an injury while for example washing or loading a vehicle). In their definition of an RTA Lehohla [5], include other land accidents such as animal riders, railway train accidents, water and air accidents. The inclusion of these other factors is a limitation when investigating transportation related fatalities.

It is important to establish a working definition of an RTA because issues may arise in the reporting of them within individual studies [1]. Inconsistent definitions within studies can result in inaccurate reports, which may underreport RTA's, thus, affecting the analysis and appreciation of their severity. For the purpose of this literature review, studies were not excluded based on RTA definition. This was done to gain an understanding of RTA in South Africa. A RTA will be defined as an accident that occurred on any road (private or public) due to a collision between two or more objects, one of which must be a moving motor vehicle.

1.3 The global impact of road traffic accidents

Injuries account for 9% of the world's deaths, claiming the lives of over 5 million people annually. In 2012, RTAs accounted for 24% of all injury-related deaths, globally [6] (Figure 1.1). Approximately, 1.2 million people died from fatal RTA associated injuries, while millions sustained debilitating injuries, affecting their way of life and in some cases inhibiting victims from working for extended periods of time or even permanently [1, 7].

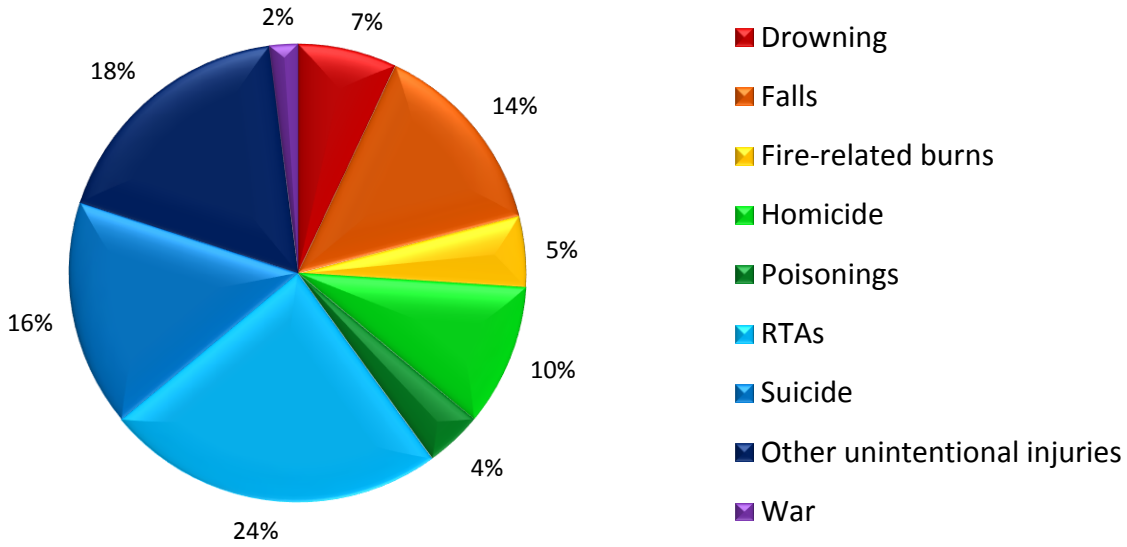

Figure 1.1 | 2012 global causes of injury-related deaths. [6]

If current trends continue, it has been predicted that the world will experience a 60% increase in RTA associated fatalities by 2020, making RTA a major contributor to the overall burden of disease [1, 8]. In 2002, RTAs were the 10th leading cause of death. However, Mathers & Loncar [9] suggest that RTAs will rise in rank, becoming the 8th leading cause of death by 2030.

Despite the fact that a minority of the population own motor vehicles, 90% of RTA associated fatalities and injuries occur in low- and middle-income countries [10-12] (Figure 1.2). According to data collected by the World Health Organization [7], in 2013, low-income countries had the highest road traffic fatality rates per 100 000 population, followed by middle-income and lastly high-income countries (Figure 1.2).

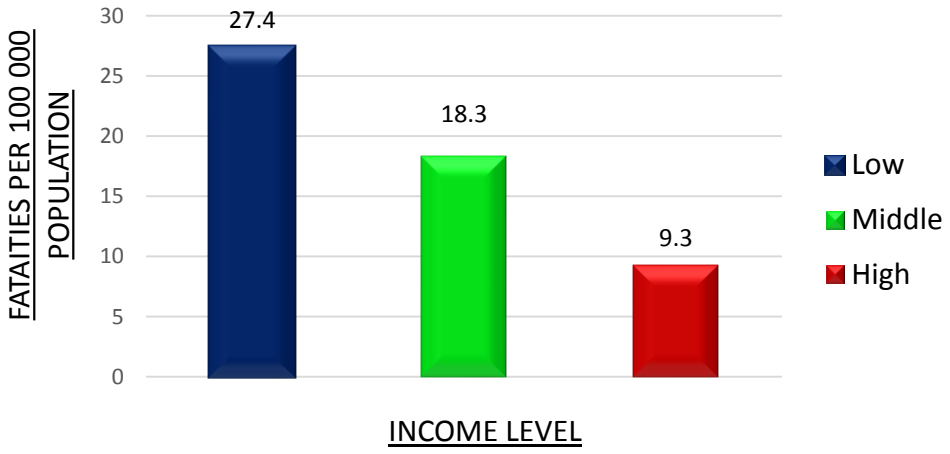

Figure 1.2 | 2013 RTA associated fatalities in terms of income level. [7]

Of the low-income countries, African countries have some of the highest RTA associated mortality rates in the world [10-12]. In 2013 the African continent was found to be the region with the highest RTA associated mortality rates with a rate of 26.6 per 100 000 population [7] (Figure 1.3).

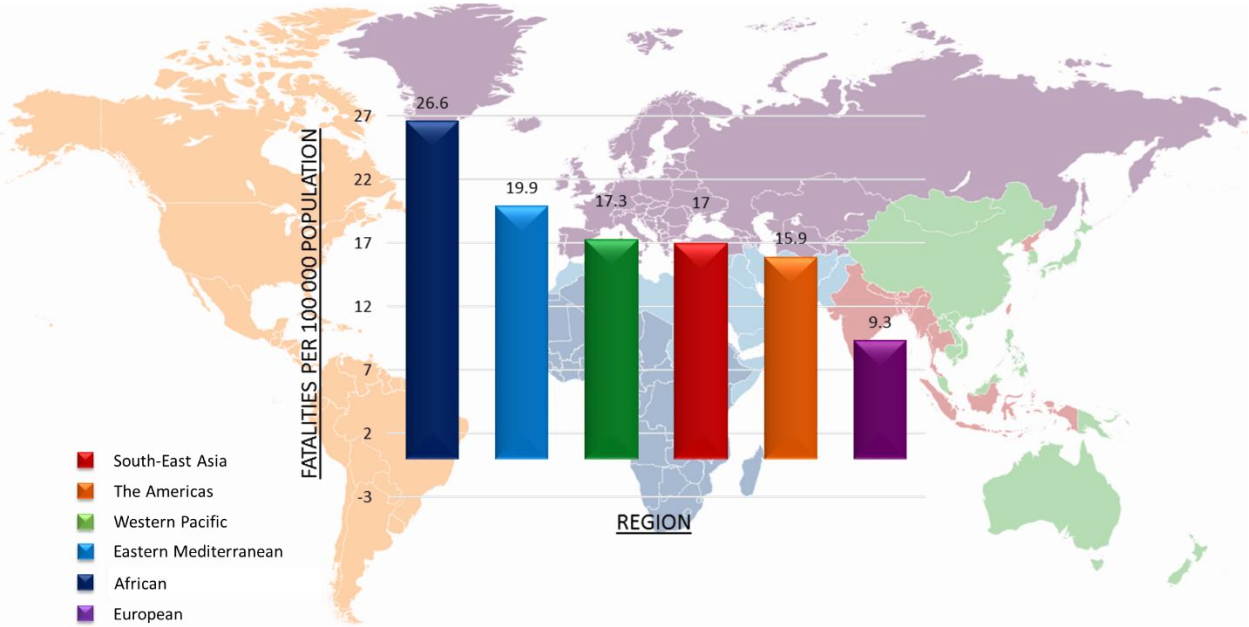

Figure 1.3 | 2013 RTA associated fatalities per 100 000 population by region [7]

RTA associated injuries and fatalities affect all age groups. However, data collected by the WHO [6, 13], suggests that this type of injury predominantly affects young people and people who are in their prime working years. In 2000, the age groups most affected by

RTAs were 15-29 years and 30-49 years (Figure 1.4). Furthermore, RTAs were found to be the second and third leading cause of death for these age groups, respectively [1]. By 2012, the age groups most affected by RTAs had not changed. However, RTAs became the number one leading cause of death for people aged 15-29 years [13].

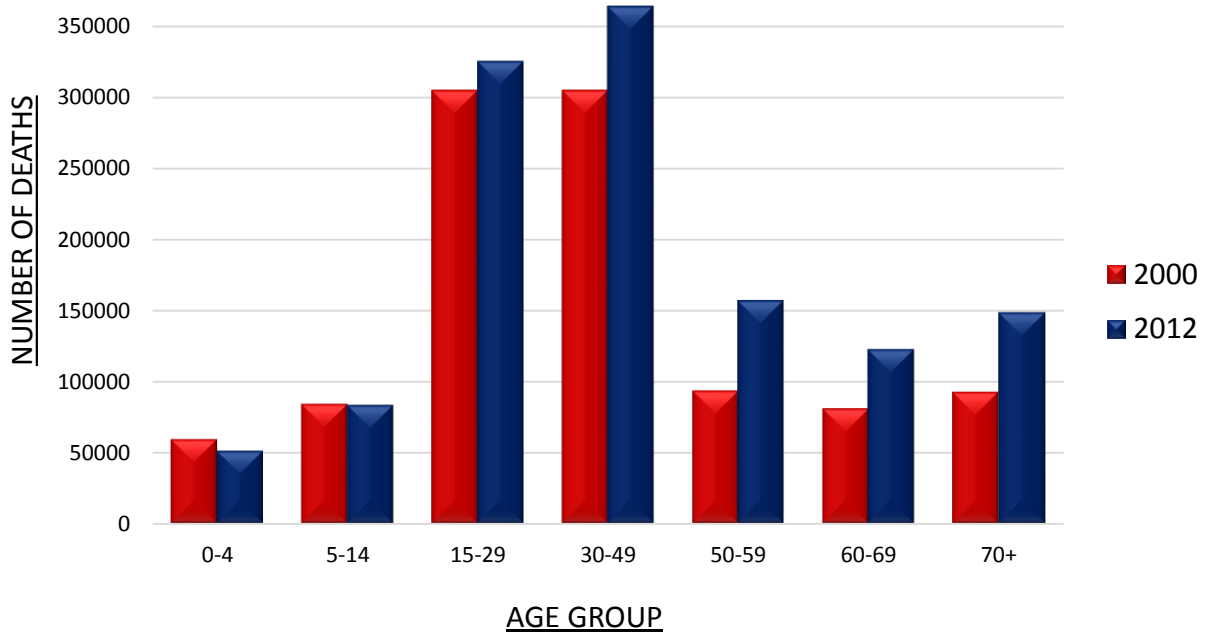

Figure 1.4 | Global age distribution of RTA associated fatalities in 2000 and 2012 [6]

The majority of RTA casualties are among the most economically productive young adults. This contributes to the inhibition of economic growth and development of a country and places additional financial, physical and psychological strain on those directly

affected by RTAs. Table 1.1, summarizes the economic burden of RTAs in some countries.

Table 1.1 | Economic costs of RTAs

COUNTRY	YEAR	% GDP	REFERENCE
Australia	2006	1.7	BITRE, 2009 [14]
India	2009	3.0	World Health Organization, 2015[7]
South Africa	2010	7.8	World Health Organization, 2015 [7]
United States	2010	1.6	Blincoe *et al.*, 2015 [15]

GDP: Gross domestic product

It is evident that the financial strain of RTAs varies from country to country and depends in part on the economic status, of the nation. Data collected by the Industrial Policy Action Plan [16] for 2010, suggests that the economic burden of RTAs is greater in developing than developed countries and it is expected that this burden will continue to increase with increased urbanisation and vehicle ownership [10-12].

1.4 Trauma associated with road traffic accidents

In forensic science, trauma is defined as any physical injury that results from a physical force or agent [17]. It is divided into three primary categories according to the mechanism of trauma; blunt force, sharp and ballistics trauma [18]. Blunt force trauma is the most common injury associated with RTAs. Blunt force trauma injuries are non-penetrating injuries, which are caused by rapid acceleration/deceleration and/or impact with a surface or object. In RTAs, blunt force results in external, hard tissue and visceral injuries. The severity of these injuries is dependent on the force applied to the tissue [19].

Typical external blunt force trauma injuries in RTAs include, include abrasions, contusions and lacerations. Knight's Forensic Pathology [19] provides an overview and description of typical external injuries associated with blunt force trauma. Briefly, abrasions are superficial injuries to subcutaneous tissue, characterized by the appearance of scratches (linear marks) and grazes (brush abrasions) on the skin surface [19]. Different types of abrasions exist (e.g. brush, crushing, fingernail, pattern abrasions) and the abrasion formed depends on the mechanism of injury to the skin. A common form of abrasion associated with RTA is caused by seatbelts abrading the skin across the torso. Contusions are bruises that lie beneath the surface of an intact epidermis, formed by the collection of blood as a result of ruptured blood vessels caused by the mechanism of impact. Contusions are not exclusive to subcutaneous tissue, they can also present themselves on deep tissue and internal organs. Lacerations are characterized by complete penetration of the full thickness of the skins as a result of tearing. Lacerations

may be differentiated from incisions (sharp trauma) by tissue bridging and a jagged appearance. There is, unfortunately, limited consensus as to what the most common type of injury sustained during an RTA is. For example, Aggarwal *et al*. [20] reported that abrasions contributed to the highest percentage (86%) of blunt force external injuries sustained RTA victims, followed by lacerations (75%) and contusions (58%). Similar findings were observed by Farooqui *et al*. [21] and Das & Gogoi [22], although they are noted contusion to be more common than lacerations. A study [23] investigating injuries sustained by motor vehicle occupants, contradicted these findings by reporting that lacerations (38.28%) were the most common type of external injury sustained, followed by abrasions (38.15%) and contusions (19.20%).

In terms of typical visceral injuries and hard tissue injuries sustained in RTAs there is also limited consensus. However, associations exist in terms of the position of the individual in a motor vehicle [24] and the site of impact [25]. It is also evident that pedestrians sustain far more extensive trauma than other road users [26].

1.5 Road traffic accidents in South Africa

Numerous studies, exploring RTAs have been conducted globally. In Africa, some of these studies have been conducted in countries such as Libya [27], Ghana [28] and Tanzania [29]. Although the information reported in these studies is useful, they cannot be used to make conclusions about RTAs in South Africa. To fully appreciate the impact

of RTAs in South Africa, studies need to be conducted in the nation. Such studies do exist and aid our understanding of RTAs in this country. These studies investigate various aspects of RTAs. However, there are limited studies regarding the injuries associated with RTA.

1.5.1 *Road traffic accident mortality and morbidity rates*

RTAs are a major contributor to the burden of disease in South Africa. In 2000, 12% of deaths were injury associated deaths attributed to RTAs, which was the 4th leading cause of years of life lost [30]. RTAs accounted for 27% of fatalities 1999 [31] and in 2001 and 2006, the number of RTA incidences and fatalities increased by 42% and 37%, respectively [32]. The most recent data released by Statistics South Africa [33] reported 6 300 RTAs in 2015 accounting for 12.1% of unnatural deaths (1.4% of all deaths) in the country. RTAs were the third leading cause of unnatural death in South Africa. Although statistics exist on RTAs, there are limited studies providing in-depth research on RTAs (Table 2.2).

1.5.2 *Economic burden of road traffic accidents*

Globally, it has been established that RTAs place an economic burden on countries. In 2000, the cost of RTAs amounted to R 13.8 billion [34]. In 2008/2009, it was reported that RTAs cost R 12 675 billion [35] and in 2010, they accounted for 7.8% of South Africa's annual GDP [7]. However, the Road Traffic Management Corporation [36] reports a

higher figure. They reported that annually, RTA associated fatalities and injuries cost South Africa R 38 billion [36].

Other aspects of RTA costs have been investigated. A previous study, reported that pedestrian injuries accounted for 13 % of the total cost of RTAs [37]. Harris & Olukonga [38] investigated how the use of preventative mechanisms can be used to reduce the economic burden of RTA. It was predicted that increasing the use of seatbelts in urban areas by an additional 16 % from a baseline of 32%, could decrease the cost of RTAs by 9.5%, saving a single province R 35.36 million [38].

Although these studies and reports serve to highlight the significant burden of RTAs in South Africa, they are limited because they do not describe where these costs come from. Parkinson *et al*. [10] attempted to do this in a study investigating the hospital cost of RTAs. Using a bottom-up micro-costing approach, this study reported that over a ten-week period the cost of in-patient care amounted to approximately R 9 million [10]. The average cost for pedestrians and motor vehicle occupants was R 88 257 and R 92 651, respectively [10]. The authors report that upper extremity injuries were the most expensive injury per patient (R 137 930), followed by pelvic injuries (R 122 772) and neck injuries (R 105 066) [10]. There are numerous studies and reports investigating the cost of RTAs. However, it is difficult to compare these studies and therefore develop an understanding of the economic magnitude of RTAs in South Africa [39].

Table 1.2 | Studies investigating RTAs in South Africa

STUDY	REGION	PERIOD	FATAL/NON-FATAL RTAS	PREVALENCE	BLUNT FORCE TRAUMA INJURIES REPORTED
Peden *et al.* (1996) [34]	Cape Town	1993	Fatal & non-fatal	-	No
Meel (2008) [35]	Mthatha	1993 - 2004	Fatal	57/100 000	No
Pretorius & Firth (2010) [36]	Gauteng	2006 - 2009	Non-fatal	-	Yes
Sukhai *et al.* (2009) [37]	South Africa	2002 - 2006	Fatal	35.8/100 000	No
Parkinson *et al.* (2013) [12]	Pietermaritzburg	2011 - 2012	Fatal & non-fatal	-	Yes
Reddy *et al.* (2013) [38]	eThekwini	5-year period	Fatal & non-fatal	-	No
Howlett *et al.* (2014) [39]	Pietermaritzburg	2011 - 2012	Fatal & non-fatal	-	No
Parkinson *et al.* (2014) [10]	Pietermaritzburg	2011 - 2012	Fatal	-	Yes

1.5.3 Road traffic accident victim demographics

During the period 2001-2006, RTAs predominantly affected individuals who fell within the age group 35-49 years, followed by 25-34 years [5]. Studies investigating different aspects of RTAs in South Africa, reported similar age groups in their findings, with some of the most affected age groups being 18-29 years [40] 21-30 years [41], 25-59 years [42] and 15-44 years [10, 11]. The loss of individuals in these age groups contributes to the economic burden of the country [6, 13]. This is because these individuals are typically young individuals who are in their most economically productive years [6, 13].

Globally, numerous studies [2, 4, 43-45] have reported that there is a greater percentage of males than females involved in RTAs. In 2002, it was reported that males made up 73% of RTA fatalities globally [46]. In Cape Town, RTAs were the fourth leading cause of death in 2001 (7.0%) and 2006 (6.7%) for males, compared to females where RTA associated death accounted for 3.8% and 3.1% in 2001 and 2006, respectively [47]. Similar findings are also reported in rural areas of South Africa. A study conducted in Mthatha reported a male to female ratio of 3:1 [41]. In other South African studies, the percentage distribution of males involved in RTAs ranges from 65 – 81%, however, in no cases were females found to be at a greater risk for RTAs than males [10, 40, 48]

It is suggested that the increased preponderance of males compared to females in RTAs can be attributed to the fact that males have a more active lifestyle with more mobility [43,

45]. This is further agitated by increased risk-taking behaviour associated with males [49]. Other risk factors associated with RTAs include fatigue, increased alcohol/drug consumption and the use of cell phones while driving [49].

1.5.4 Risk factors

The risk factors associated with RTAs have been investigated extensively globally. These risk factors have been explored in South Africa. The University of Natal's Accident Research Centre [50], reported that human factors (78%) were the main reason responsible for RTAs, followed by environmental factors (12%) and vehicle factors (10 %). Human factors include speed, alcohol and drug use, driver fatigue, and cell phone use, while environmental factors include crash scene light, weather, location and road surface [1]. Similar findings were reported by Kyei & Masangu [51], where human factors such as high speed (47.3%), jaywalking (39.0%), unlawful/unsafe overtaking (7.2%), hit and run (6.5%), where also the main cause for RTAs (80.1%). Environmental and vehicle, related factors were reported to be responsible for 11.5% and 8.4% of RTAs, respectively [51].

Rural regions may, however, differ slightly in the attributed risk factors. A study investigating RTAs in Mthatha (semi-rural region in the Eastern Cape province of South Africa), attributed RTAs to poor roads, poor health and communication systems, reckless driving and unroadworthy vehicles [41]. Regions which are more economically stable

typically have improved infrastructure and better access to health care structure, both of which may result in fewer deaths associated with RTAs. Further risk factors include; jaywalking (particularly across major highways), speeding and the use of alcohol [52].

1.5.4.1 *Road traffic accident and alcohol impairment*

Alcohol consumptions is a global phenomenon and has been shown to lead to drunkenness and violence [53, 54]. South Africa has been described by Seggie [55] as a "hard drinking" country, consuming more than five billion litres of alcohol every year [56]. In 2009, 10-12% of the country's gross domestic product was spent on the tangible and intangible costs of harmful alcohol use [56]. It was predicted in 2006, that the cost of alcohol-related RTAs would amount to R 7.9 billion [57]. In 2010, the Road Management Traffic Co-operation reported that alcohol-related RTAs cost South Africa R 180 billion [58].

The effect of alcohol misuse in South Africa is a growing public health concern and have had a huge impact on the justice system in the country [59, 60]. Studies have shown that an association exists between alcohol use and risk-taking behaviour [59, 60]. Alcohol use may also impair judgement and slow down the reaction times of an individual [61]. Such effects can have disastrous consequences for road users, including vehicle occupants as well as pedestrians. It has been reported that in South Africa alcohol was a contributing factor in 29.1% of non-fatally injured drivers [62] and in 47.4% of fatally injured drivers

[63]. A study predicted that 24% of fatal and non-fatal RTAs could be prevented if drivers were not behind the steering wheel while under the influence of alcohol [64]. A legal alcohol limit has been set for drivers in South Africa to discourage drinking and driving. Within South African legislation (National Road Traffic Act 92 of 1996), the legal limit for the presence of alcohol for professional drivers is set at 0.02 g/100 mL and for normal drivers at 0.05 g/100 mL. At BAC levels between 0.0 – 0.05 g/100 mL, the clinical signs and symptoms are normal behaviour, mild euphoria and reduced reaction time [65]. The clinical signs and symptoms at BAC levels between 0.05 – 0.01 g/100 mL include impaired coordination, slow reaction time, decreased judgment, slow reaction time and decreased sensory response to stimuli [65].

Previous studies have reported BAC levels in fatal RTAs in South Africa. BAC levels greater than 0.05 g/100 mL were reported in 57.2%, 30.7%, 46.5% and 35.6% for pedestrians, passengers, drivers and cyclists, respectively [1]. A recent study investigating the presence of alcohol in all medicolegal autopsies in Pretoria, reported that 37% of the cases analysed were RTAs [40]. Within these RTA cases, alcohol was present (BAC > 0.01 g/100 mL) in 52% of the cases. The average BAC for drivers and pedestrians was 0.17 ± 0.09 g per 100 mL and 0.22 ± 0.11 g per 100 mL, respectively, which is far above the South African legal limit of 0.05 g/100 mL.

Although pedestrians are often reported as the most intoxicated road user, the country's legislation is directed at controlling driver impairment; there are no laws directly governing

alcohol use for pedestrians in South Africa. Such laws do exist in various states (such as Alabama, Idaho, Illionois, and Kansas) in United States of America.

A study investigating pedestrian fatalities across four cities in South Africa found that 58% of cases tested positive for alcohol, with 42% of these cases having a Bac greater than 0.24g/100ml [66]. Pedestrian safety education programs exist; however, these programs do not always communicate the risk of alcohol use and pedestrian behaviour [67]. Research suggests that alcohol limits for pedestrians should be introduced [67].

1.5.4.2 *Road traffic accident and drug impairment*

Alcohol is the most commonly abused drug and its effect has been researched extensively. However, research is now showing an increased prevalence of drug use in fatal and non-fatal RTAs. Out of treatment drug users (87%) reported driving immediately after taking illicit drugs, mainly heroin and cocaine [68]. Out of these drug users, 41.4% were involved in at least one RTA following drug consumption [68]. A United States-based study reported that drug positive prevalence in fatally injured drivers increased by 49% from 1999 - 2000 to 2009 - 2010 [69]. A study conducted in Sweden showed that 80 - 85% of samples collected from fatally injured drivers tested positive for at least one banned substance with amphetamine being the most detected drug [70]. In another study, illicit drugs were detected in 25% of drivers involved in RTAs [71]. Cannabis was the most detected drug, followed by benzodiazepines, cocaine, amphetamines and opioids [71].

Although limited, the epidemiology of drug abuse in South Africa has been investigated. A study conducted by Peltzer *et al*. [72] investigated the types of drugs seen in substance abuse treatment centres. The primary illicit substance reported was cannabis (16.9%), followed by methamphetamine (tik) (12.8%), crack cocaine (9.6%), heroine/opiates (9.2%), cannabis and mandrax (3.4%) and prescription/over the counter medication (2.6%). Another study based on admissions at substance abuse treatment centres, showed that after alcohol (51%), cannabis (21%) was the most abused drug. This was followed by crack cocaine (4.5%), prescription/over the counter medications (2.0%) and cannabis and mandrax (1.7%) [73]. There have however been no studies investigating the role of drugs in RTAs. One of the challenges faced is the lack of forensic toxicological data available. This is because, unless suspected, drugs are not routinely tested for in post-mortem RTA cases. The problem with this, as Mercer & Jeffrey [74] pointed out is that in RTA cases, alcohol and drug impairment is mistakenly interpreted as alcohol impairment only and drug impairment is identified as “driving without care and attention”. It is evident, there is a need to further investigate the use of drugs among victims of RTAs in South Africa.

1.5.5 Road traffic accident preventative mechanisms

Road transportation preventative mechanisms are put in place to reduce RTA mortality and morbidity rates. In South Africa, although limited, studies have been conducted investigating the efficiency of preventative mechanisms that have been put in place. Reddy & Knight [75] investigated the effect of traffic calming humps on pedestrian-vehicle

collisions in two different areas of eThekwini Municipality, Durban. This study reported that the introduction of traffic calming humps resulted in the reduction of non-fatal RTAs by 23% and 22%, while fatal RTAs dropped by 68% and 50% in Chatsworth and Kwamashu, respectively [75].

An in-depth review of traffic calming strategies was conducted in Cape Town. This review concluded that a significant decrease in traffic speeds (up to 30%), volumes (up to over 70%), resulted in a reduction of RTAs (by between 16% to 90%) from the base case. However, unlike the study conducted by Reddy & Knight [75], this study was not based on an extensive literature review. Nonetheless, the study provides valuable insight into the degree of success of road traffic calming strategies in Cape Town.

1.5.6 Road traffic accident associated blunt force trauma

Studies regarding RTAs are limited, especially when it comes to RTA associated injuries. The main issue with SA based studies regarding RTA associated blunt force trauma injuries, is that the research lacks depth and detail. A study carried out by Parkinson *et al*. [10], investigating the hospital cost of RTAs, reported that upper limb injuries were the most expensive injury to treat. However, this study did not provide insight into specifics about the types of injury (e.g. soft tissue versus hard tissue), the severity of injuries and the road user obtaining these injuries. In another study Parkinson *et al*. [11] provided more detail about the type of upper limb injuries observed in RTA victims. However, this

information is limited to hard tissue injuries, and in lower limb injuries even less information is provided. This is an issue with similar studies where fractures are often noted but not described in any great detail, or the mechanism of injury is not fully investigated.

Parkinson *et al*. [12] conducted another study in 2013 comparing the pattern of injuries obtained by pedestrians (PED) with those obtained by motor vehicle occupants. Their findings suggested that motor vehicle occupants sustained neck, abdominal and upper arm injuries, while pedestrians sustained injuries to the lower extremity, upper limbs, head and torso. Despite the fact that details of the mechanism of injury were not explored, the difference between the injuries observed, illustrate how the mechanism of injury informs the type of injuries obtained by RTA victims. This study provides valuable information to enhance the distinction between road users in RTAs, which may have forensic significance. However, with the exception of upper and lower extremities, the study did not investigate the types of injuries observed in the different regions. In addition to this, the study did not describe the differences in the injuries obtained by different people within a vehicle, such as the driver or passenger(s).

In comparison to Parkinson *et al*. [12], Bowely and Boffard [76] investigated injuries associated with RTA including an analysis of the mechanism of injury obtained by pedestrians. Their findings revealed that an upright adult pedestrian hit by the bumper of a motor vehicle was more likely to sustain injuries to the lower extremities [76]. If the

pedestrian was hit by the windscreen they were more likely to obtain injuries to the torso and head, while impact with the ground resulted in head, spinal and other injuries [76].

The injuries obtained by children has also been investigated. A study [77] conducted in Gauteng reported that lower limb fractures (33.5%) were the most frequent, followed by fractures to the upper extremities (5.5%) and pelvic fractures (4.1%). Visceral injuries were not reported; neither was the mechanism of injury investigated. Despite this, however, the study does provide useful insight into the type of injuries obtained by children. However, this type of research is limited in South Africa.

1.6 Conclusion

Road transportation systems are a developmental achievement. However, with them came increased global morbidity and mortality rates. In South Africa, RTAs pose a huge economic and psychological burden on the country. A greater preponderance of males to females are involved in RTAs, most of whom fall within the most economically productive age group. The use of alcohol and drugs in RTAs has been identified. However, the extent of alcohol and drug-impaired in RTAs has not been fully established. In addition to this, factors other than alcohol and drug use, are rarely quantified within literature. Many aspects of RTA associated blunt force trauma have been investigated internationally. However, very few studies exist in South Africa.

In South Africa, RTAs are a complicated issue to study. This can be attributed to the economically diverse population, varying road conditions and different road users, which make data collection both challenging and unique [78]. However, the burden of RTAs calls for more research and this research needs to pay particular attention to RTA associated injuries, the road user and the context in which these RTAs are occurring. The purpose of this study is to investigate the demography surrounding RTAs in a region of Cape Town and the injuries associated with them. This information can then be used in the identification of the mechanism of injury, which will then inform the road safely mechanisms and the traffic laws required to reduce the prevalence of RTAs in South Africa.

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CHAPTER TWO:

Publication Ready Manuscript

RETROSPECTIVE ANALYSIS OF BLUNT FORCE TRAUMA ASSOCIATED WITH FATAL ROAD TRAFFIC ACCIDENTS IN CAPE TOWN (SOUTH AFRICA) OVER A TWO-YEAR PERIOD.

T. A. Tiffany Majero*

[1]Department of Pathology, Division of Forensic Medicine and Toxicology, Faculty of Health Sciences, University of Cape Town.

*Correspondence to: T. A. Tiffany Majero, Department of Pathology, Division of Forensic Medicine and Toxicology, Faculty of Health Sciences, University of Cape Town, P.O. Box 13914, Mowbray, 7705, South Africa. E-mail: tiffanymajero@icloud.com

2.1 ABSTRACT

Currently, in South Africa, there is limited information regarding the prevalence of road traffic accidents and the blunt force trauma injury patterns associated with them. The purpose of this study was to determine the prevalence of fatal road traffic accidents and the characteristics of associated blunt force trauma injuries in the West Metropole region of Cape Town (South Africa). A retrospective analysis was conducted of all fatal road traffic accidents autopsied at Salt River Mortuary (which serves the West Metropole region of Cape Town), from January 1st, 2013 to December 31st, 2014. All deaths that were not determined to be due to road traffic accident associated blunt force trauma by the pathologist were excluded. The prevalence of fatal road traffic accidents for 2013 and 2014 were 16.2/100 000 and 15.5/100 000, respectively. The majority of road traffic accident victims were males who fell in the age group of 30 – 49 years. Over the two-year period, the majority of road traffic accident victims were pedestrians with elevated blood alcohol concentration levels. The body regions which presented the most associated blunt force trauma were the head and face for external injuries and the head and chest for hard tissue and visceral injuries. It was determined that pedestrians were the most vulnerable road user and that in order to develop appropriate preventative mechanisms, further research is required in order to determine what factors make them more vulnerable

2.2 INTRODUCTION

Road transportation systems are a global development. However, this achievement may be responsible for increasing global mortality and morbidity rates around the world. Approximately, 1.2 million people die annually in road traffic accidents (RTAs), while millions of survivors sustain debilitating injuries [1]. It has been predicted that RTA associated fatalities will increase by 2020, making RTAs the lead contributor to the overall burden of disease [1, 2].

90 % of RTA associated fatalities occur in low- and middle- income countries, with Africa having some of the highest mortality rates in the world [3-5]. It has been predicted that these rates will continue to increase with increased urbanisation and vehicle ownership [3-5]. In Africa studies investigating this phenomenon have been conducted in Libya [6], Ghana [7] and Tanzania [8].

In South Africa, the economic burden of RTAs has also been investigated. The incidence of RTA and associated fatalities increased by 42% and 37%, respectively, from 2001 – 2006 [9]. In 2006, RTAs were responsible for the loss of an average of 27 people daily [9]. In 2008/2009, it was estimated that RTAs cost the economy R12 675 billion [10]. Other South African based studies have investigated the hospitalisation cost of RTAs [5], the relationship between alcohol and RTAs [11] and in general, the injury patterns sustained by RTA victims [4]. These studies highlight the severe and increasing burden of RTAs,

however, it is still necessary to conduct further research particularly relating to the prevalence of RTA associated fatalities and the injuries associated with such deaths.

Blunt force trauma injuries are characteristic of RTAs and are the primary type of injury seen in such cases. Studies investigating RTA associated blunt force trauma injuries in South Africa have been conducted [4, 5, 12]. However, these studies are limited to regions of the body injured and the fractures sustained. These studies do not provide an in-depth analysis of the injuries observed. In addition to this, they do not investigate the relationship between the type of injuries observed and road user. No studies characterizing the pattern of injury observed in RTA, exist for the Western Cape. In order to reduce the morbidity and mortality rates of RTAs, an understanding of the types of injuries obtained needs to be established.

Therefore, the aim of this study was to investigate RTA associated blunt force trauma injuries, the road user and the context in which these RTAs occur. This information can then be used in identifying the mechanism of injury, which can then inform the road safety mechanisms and the traffic laws required to reduce the prevalence of RTAs in South Africa.

2.3 METHODS

A retrospective investigation of all fatal road traffic accident (RTA) autopsied at Salt River Mortuary (Cape Town, South Africa) from 1 January 2013 to 31 December 2014 was conducted. Salt River Mortuary is classified as a level six academic facility, which serves the West Metropole region of the city of Cape Town (Figure 2.1). It receives in excess of 3 000 cases per year [13].

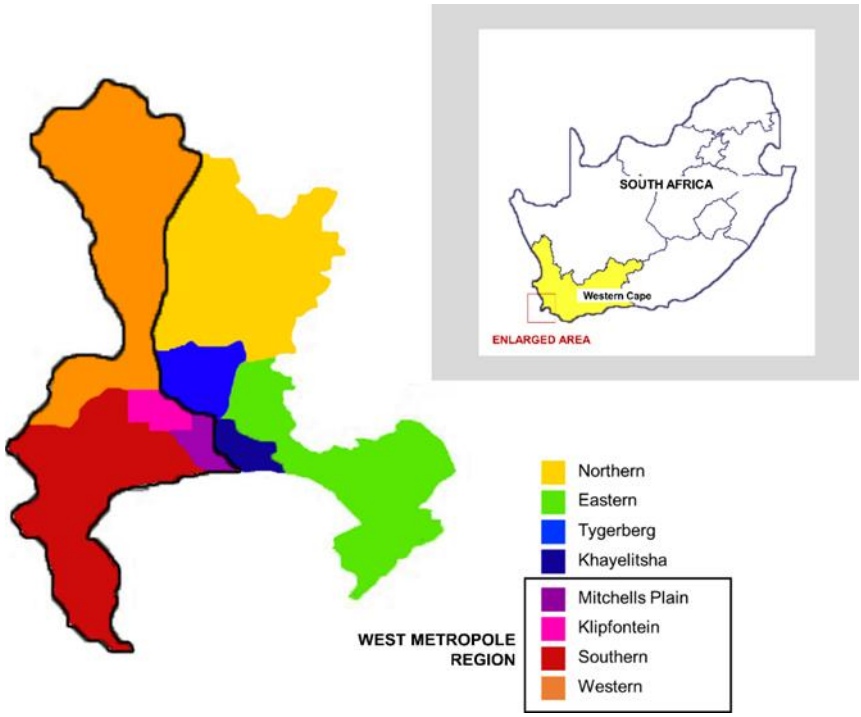

Figure 2.1 | Map of the greater Cape Town area indicating the service region of Salt River mortuary (West Metropole of the city of Cape Town)

For the purposes of this study, a RTA was defined as a collision between two or more objects (one of which had to be a motor vehicle). Cases were excluded if injuries occurred on the road but did not involve at least one motor vehicle (a motor vehicle was defined as a self-propelled device that is used as a means of transport for passengers or cargo on roads)RTA cases were also excluded if death was not determined by the pathologist as due to RTA associated blunt force trauma injuries. In addition to this, cases were excluded from further analysis when the injuries described by the pathologist were challenging to interpret.

Information was extracted from the original autopsy files. and was recorded in a Microsoft® Office Excel® 2013 (Microsoft, Redmond, Washington, USA) database. The data was exported into Stata Version 13.1 (StataCorp, Texas, USA), where descriptive statistical analysis was carried out. Associations between different variables were analysed using the Pearson's Chi-Squared ($\chi 2$) test. Population Data was obtained from the 2011 National Census Data from Statistics South Africa [14]. A summary list of the suburbs forming part of the service area and their relevant population sizes can be found in Appendix C.

Ethical approval for this study was granted by the Human Research Ethics Committee (HREC) of the Faculty of Health Sciences at the University of Cape Town (HREC REF: 165/2016).

2.3 RESULTS AND DISCUSSION

2.4.1 Prevalence of RTAs

RTAs form a substantial proportion of deaths worldwide. A study utilizing data from the National Injury Mortality Surveillance System (NIMSS), suggested that the road traffic mortality rate in South is double the global rate of 26.7% of injury-related deaths accredited to road traffic injuries [15].

At Salt River Mortuary, a total of 3 346 and 3 461 autopsies were conducted in 2013 and 2014, respectively. Of these deaths, 314 (9.4%) and 301 (8.7%) were as a result of RTAs. Based on population data from the 2011 national census, the prevalence of fatal RTAs for 2013 and 2014 were 16.2/100 000 and 15.5/100 000, respectively. Comparison of these values to previous studies conducted in the Western Cape, was challenging, because such studies are limited. However, when compared to other regions in South Africa the prevalence of RTAs observed in these study were considerably less than the prevalence reported study that investigated fatal RTAs in Mthatha, Eastern Cape South Africa (57/100 000) [16]. This study used medico-legal autopsy files to collect its data. In contrast to the West metropole region of the city of Cape Town (predominantly mid- to high socio-economic status), the Mthatha region is a largely impoverished rural area. It has previously been demonstrated that the prevalence of RTAs is inflated in poorer, rural regions [17, 18]. This is as a result of poor roads, poor health and communications

system, reckless driving and unroadworthy vehicles [16]. When compared to other provinces in the country, the prevalence of RTAs in this study was less than the prevalence (18.1/100 000) reported for Limpopo, but greater than the prevalence (5.9/100 000) reported for Gauteng between 2001 and 2006 [19]. Differences in the prevalence of RTAs are expected between countries and within a country because of the differences that exist in terms of the volume of vehicles, the density of road networks, road safety mechanism and the behaviour of road users.

2.4.2 Demographic distribution of RTAs

2.4.2.1 *Distribution of RTAs by age*

Figure 2.2 illustrates the age distribution of RTAs. The age ranges used are the same as those used by the WHO. According to data collected by the WHO, in 2000 and 2012, the age groups most affected by RTAs were 30 - 49 years, followed by 15 – 29 years [20]. These were the same age groups most affected by RTAs in the current study (Figure 2.2). The mean age group of individuals involved in RTAs was 34 years (SD = 16.80; range 1 – 87 years). The highest incidence of fatalities occurred in the age group of 30 - 49 years (44.95%), followed by 15 – 29 years (25.08%). It is important to note, that further analysis is needed to more accurately define exactly who is at risk.

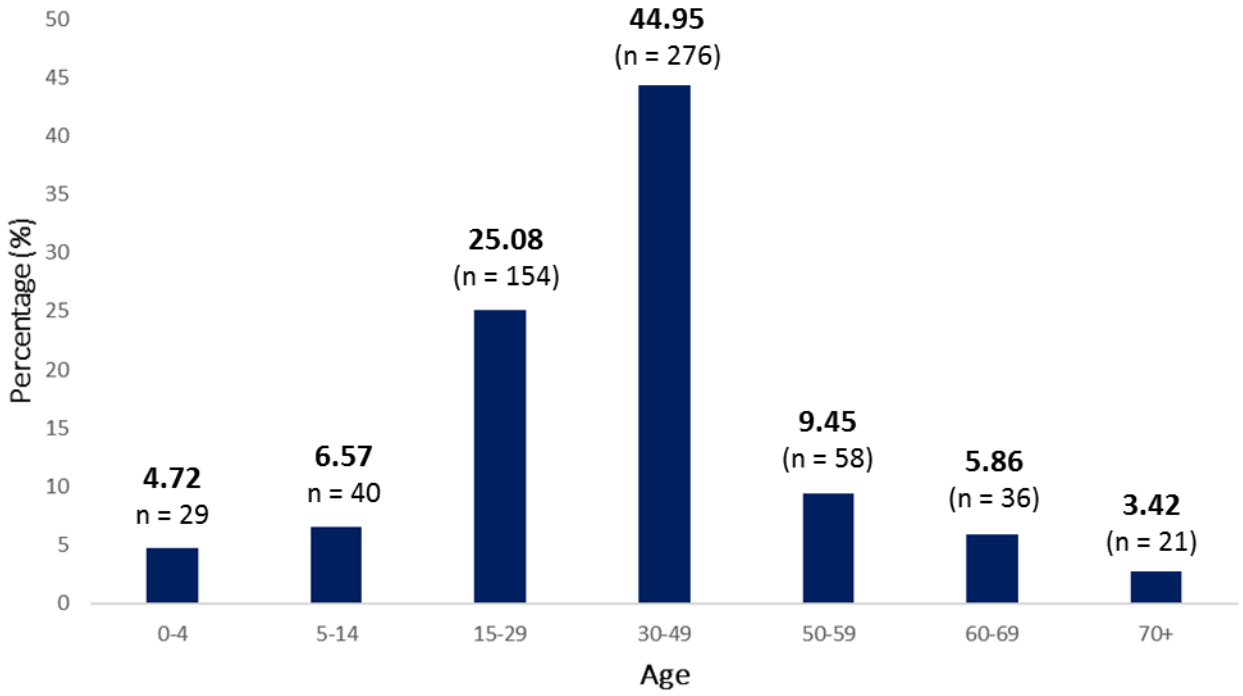

Figure 2.2 | Percentage age distribution of road users involved in RTAs.

The findings in this study concur that globally over 50% of RTAs involve individuals who are aged between 15 – 44 years [21]. Individuals who form part of this age group are in their most active and productive years. The loss of these individuals has a huge economic impact on family members and the nation [22, 23]. It is, therefore, important to implement appropriate preventative and safety mechanisms in order to reduce the risk of these age groups to RTAs. However, before this can be done, more research investigating the risk factors (e.g. use of restraint methods, experience behind the wheel, drugs and alcohol, etc.) specifically associated with these age groups needs to be conducted.

The findings in this study showed that the proportion of RTAs in the age groups that were less than 15 years and greater than 50 years were low. This is because individuals who fall within these age groups are presumed to be less mobile and are therefore less likely to be exposed to RTAs [22].

2.4.2.2 *Distribution of RTAs by sex*

In this study, there was a higher percentage of males (82.60%) than females (17.40%) involved in RTAs (ratio = 4.75: 1). The male predominance observed in this study is in accordance with other studies of this nature [22, 24]. It is suggested that males are more exposed to RTA as studies suggests that males have a more active outdoor lifestyle with more mobility [24]. In addition to this, when compared to women, men have a greater risk-taking attitude on the road [1].

2.4.3 Distribution of RTAs by road user

In the current study, RTA victims were divided into five categories according to road user, namely: cyclist, driver, motorcyclist, passenger and pedestrian. It is important to note that further classification of road users (e.g. sub-classification of passengers according to their seating position) would be beneficial in conducting a more in-depth analysis of the type of injuries obtained by various road users. However, the information required in order to conduct this type of analysis is often not reported in medicolegal autopsy files.

In this study, the greatest percentage of RTA deaths were among pedestrians (58.21%), followed by drivers (17.24%), passengers (14.63%), motorcyclists (8.29%) and cyclists (1.63%) (Figure 2.3). Similar findings were reported by Matzopoulos *et al.* [18], where pedestrian fatalities accounted for 40%, of RTAs followed by drivers (22.9%) and passengers (32.6%).

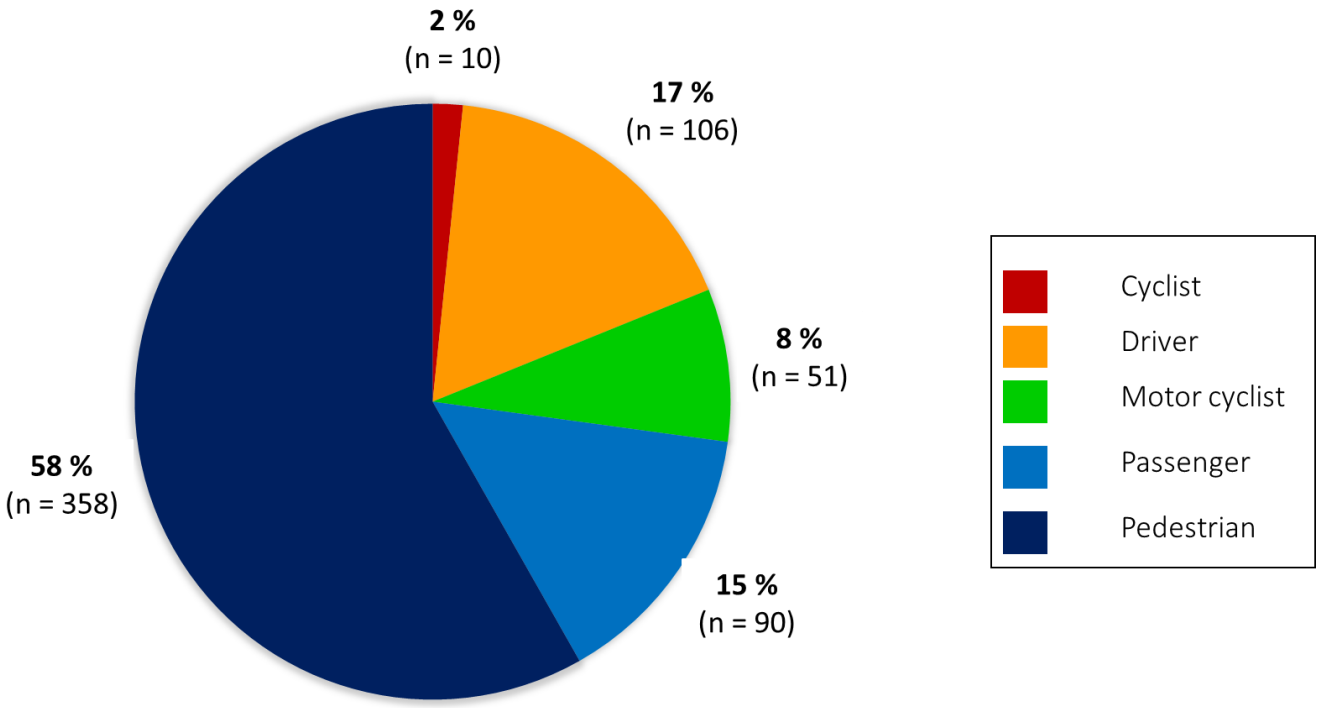

Figure 2.3 | Percentage distribution of RTA fatalities by road user

Previous studies [25-27] conducted in developing countries, substantiate the increased susceptibility of pedestrians to RTAs. The vulnerability of pedestrians could be attributed to the lack of awareness of road safety mechanisms and practices. A Kenyan based study

[8], reported that 92% of police respondents felt that the lack of awareness of the high way code by pedestrians was one of the reasons why they were the most vulnerable road user. In South Africa, research investigating pedestrian behaviour is limited. However, the high percentage of deaths occurring among pedestrians observed in this study, suggests that the current laws regulating pedestrians may be inefficient. In order to reduce the exposure of pedestrians to RTAs, research investigating pedestrian behaviour is required, so that reasonable pedestrian laws can be created and enforced [28]. In addition to this, there is a need for campaigns designed to educate and encourage pedestrians to adopt good road safety practices.

Comparison of the findings in this study with studies conducted in other African countries such as Cote d'Ivoire [25], Ethiopia [25], Kenya [26] and Nairobi [27] revealed that the highest proportion of RTA deaths were also among pedestrians. However, in countries in South-East Asia, motorcyclists contributed the most to RTA fatalities, while in the United States of America, drivers were the most vulnerable road user [29]. Studies investigating the distribution of road users in RTA fatalities have shown that it varies dramatically between different countries [30]. The difference between countries is due to differences in the type of traffic, the proportion of road users, and the nature of RTA [1].

2.4.4 Temporal distribution of fatal RTAs

2.4.4.1 *Time of day*

Odero *et al.* [31] reported that in developing countries between 60-80 % of RTA fatalities occurred during the day with only a third of them occurring at night between 1800-2400 hrs. A similar observation was made in a Jamaican based study conducted by Crawford & McGrowder [22] where the greatest incidence of RTA fatalities occurred between 0600-1800 hrs. The reason for the increased incidence of RTAs during the day may be attributed to an increased traffic load of individuals travelling to and from work or school [31]. The majority of studies report elevated levels of RTAs during the day, however, a few studies do report a greater incidence of RTAs at night [31, 32], as was the case in the current study.

In the current study, the majority of fatal RTAs occurred between 1800-2400 hrs. (37.52%) followed by 0000-0559 (22.13%). Although traffic density at night is less, poor visibility, increased speed, fatigue and increased risk-taking behaviour escalates the risk of RTAs [31, 33, 34]. Delays in injury reporting and less efficient medical services at night [31] may also contributed to increased risk of RTAs occurring at night, where adequate infrastructure and medical support are not readily available.

Differences were noted in the time of death of different road users (Figure 2.3). Motor vehicle occupant fatalities had two substantial peaks at 0000 – 0559 and 0600 – 1159. In contrast pedestrian fatalities gradually increased throughout the day, with the highest percentage of deaths (65.71%) occurring between 1800-2359. After which the number of fatalities decreased (Figure 2.4). A significant difference (p = 0.0001) between road user and time of death was observed between pedestrian and motor vehicle occupant fatalities. The difference observed could be attributed to the differences in the density of these road users during these time zones. However, the relationship between road user density and time of death has not been fully explored.

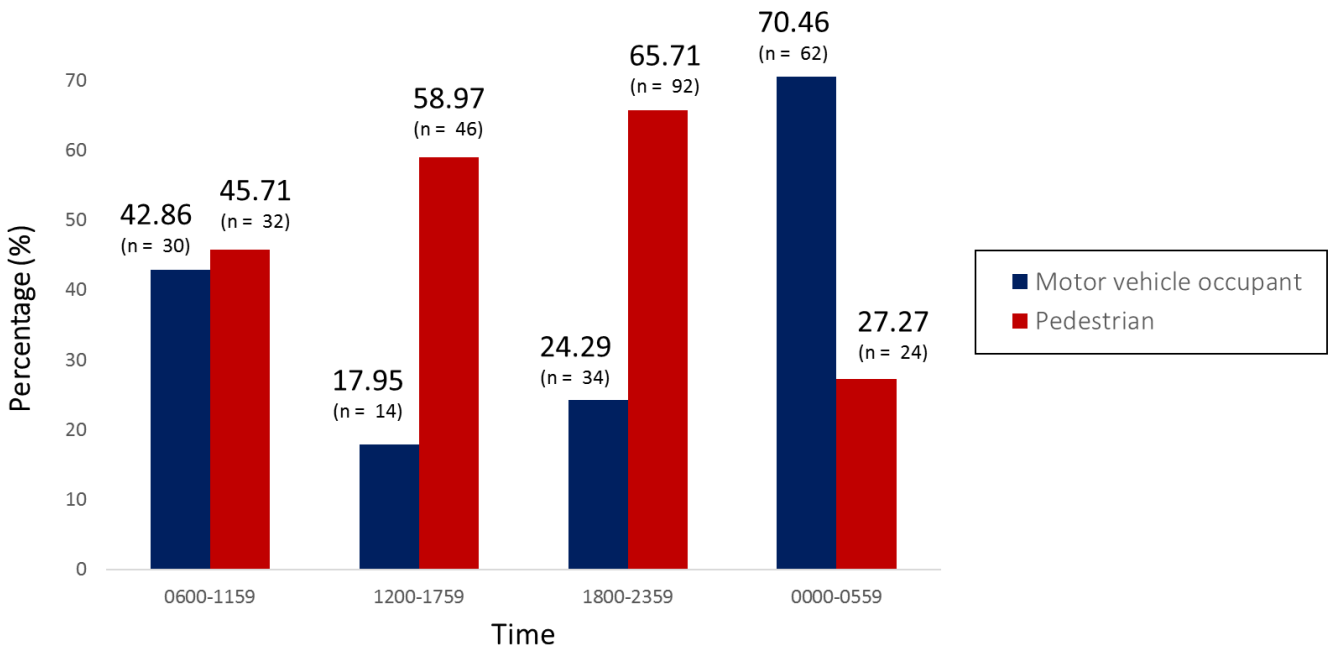

Figure 2.4 | Comparison between time of death and pedestrian versus motor vehicle occupants.

2.4.4.2 *Day of the week*

Over the two-year period, 50.56% RTAs occurred during the week (Monday – Friday), while 49.44% of RTAs occurred during the weekend (00h00 Saturday morning to 24h00 Sunday night). The greatest number of RTAs was observed on Saturday (26.67%), followed by Sunday (22.78%). In studies conducted in Ethiopia [35] and India [36] the greatest incidence of RTAs was also observed on Saturday. Even though, there is a decrease in traffic density during the weekend, the risk of RTAs is high because of other factors such as alcohol and drug intoxication [31].

2.4.5 Survival period

Over the two-year period, 58.37% of RTA victims died at the scene, 38.70% died after hospitalisation and 2.93% died en route to the hospital. Of the hospitalised RTA victims, 34.21% survived less than 24 hours and 65.78% survived more than 24 hours (Figure 2.5). The mean survival time after admission to hospital was 4.84 hours (min < 1 hour; max 21.0 hours) in the < 24-hour group and 11.78 days (min: 1 day; max: 178 days) in the > 24-hour group. Survival time is linked to the severity and extent of injuries as well as the quality of treatment a patient receives. However, post-operative complications and infections may further compromise an individual's chance of survival. Furthermore, the longer a RTA victim stays in hospital, the greater the risk of developing complications that may lead to death [37]. Thus, it is not surprising that the majority of hospitalised patients

in fatal RTAs, succumb to their injuries after 24hrs of hospitalisation. Increased mortality rates of RTAs in third world countries are often attributed to insufficient and poor emergency medical services [32, 38]

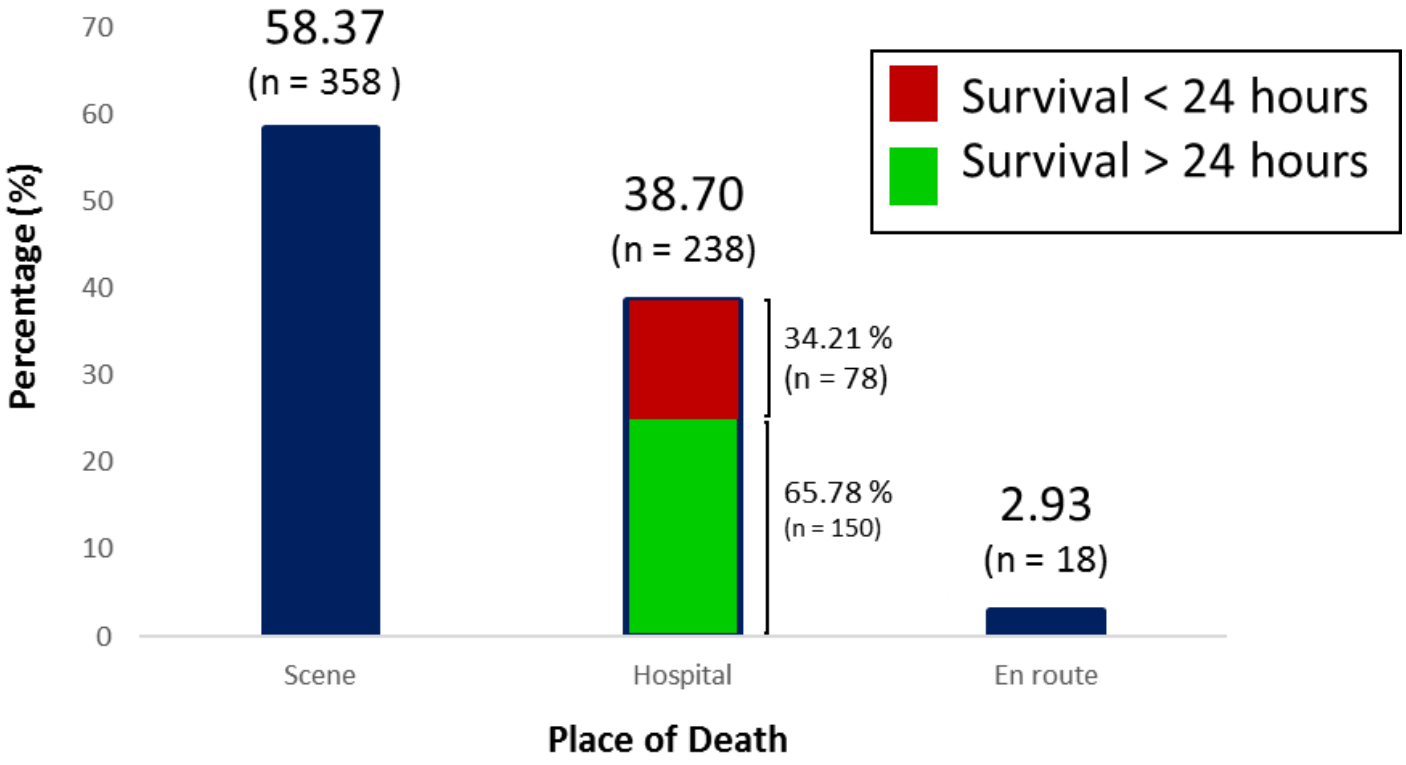

Figure 2.5 | Place of death and survival period after admission

2.4.6 Toxicology and RTAs

2.4.6.1 Alcohol intoxication

South Africa has been described as a “hard-drinking country” consuming more than 5 billion litres of alcohol annually [39]. Matzopoulos *et al.* [40] reported that in 2009 the tangible and intangible costs of harmful use of alcohol to the economy amounted to R300 billion, which was 10-12% of the country’s gross domestic product. A strong correlation exists between intoxication and RTAs.

In the current study, it was noted that alcohol analysis was requested in 66.55% of the autopsies reviewed. The reason why blood alcohol analysis was not conducted in all cases is because in South Africa, specimens for analysis are collected at the pathologists’ discretion. Blood was the most common specimen taken for alcohol analysis (66.02%) and vitreous humour was used as a specimen in 0.53% of the cases. At the time of writing BAC results were present in 69.74% of the cases. The blood alcohol concentration (BAC) was expressed in grams per 100 millilitres (g/100 mL). A BAC of ≥ 0.01 g/100 mL was considered a positive detection of alcohol. Of the cases where alcohol analysis was conducted, and results were available, alcohol was detected in 50.18% of the victims with a mean BAC of 0.091 g/100 mL. Findings in this study are comparable to other South African based studies conducted by Ehmke et al. [41] and du Plessis *et al.* [42] where 52.0% and 50.3% respectively, of RTA victims tested positive for alcohol.

Table 2.1 | Distribution of the presence of alcohol, intoxication and BAC levels per road user

		Road User					
		Cyclist	Driver	Motorcyclist	Passenger	Pedestrian	Total
PRESENCE OF ALCOHOL	*n (%)*						
	Positive [a]	1 (33.33)	30 (52.63)	12 (46.15)	20 (46.51)	72 (51.06)	121
	Negative [b]	2 (66.67)	27 (47.37)	14 (53.85)	23 (53.49)	69 (48.94)	149
	Total	3	57	26	43	141	270
PREVALENCE OF INTOXOCIATION	*n (%)*						
	Intoxicated [c]	1 (33.33)	25 (43.86)	10 (38.43)	18 (41.86)	67 (47.52) *	121
	Not intoxicated [d]	2 (66.67)	32 (56.14)	16 (61.54)	25 (58.14)	74 (52.48) *	149
	Total	3	57	26	43	141	270
BAC LEVELS	**g/100 mL**						
	Mean	0.34	0.153 ± 0.08	0.148 ± 0.07	0.154 ± 0.08	0.206 ± 0.09	
	Range	0.34-0.34	0.02-0.31	0.03-0.26	0.04-0.34	0.02-0.41	

[a] BAC ≥ 0.01 g/100 mL
[b] BAC 0.00 g/100 mL
[c] BAC ≥ 0.05 g/100 mL
[d] BAC < 0.05 g/100 mL

* Indicates significant difference ($p < 0.05$)

The distribution of the presence of alcohol according to road user was investigated (Table 2.1). Drivers (52.63%) were the most prevalent road user with the highest percentage of fatalities with a positive BAC. Pedestrians (51.06%) were found to have the second highest percentage of fatalities with positive BAC results. Drivers involved in fatal RTAs were more likely to have positive BAC results than pedestrians ($p = 0.0001$).

The results demonstrated that in cases where alcohol was detected, 44% of the victims' BAC levels were over the South African legal driving limit (0.05 g/100 mL), as governed by the National Road Traffic Act (92 of 1996). The mean BAC of these cases was 0.192 ± 0.08 g/100 mL ranging between 0.05-0.41 g/100 mL.

Table 2.1 indicates that the mean BAC for each road user group was far greater than 0.05 g/100 mL. The same observation was made by du Plessis *et al.* [42]. Cyclists had the overall highest mean BAC (0.34 g/100 mL). However, this group only contained three cases, only one of which was positive for the presence of alcohol. Pedestrians had the second highest mean BAC (0.206 ± 0.09 g/100 mL) followed by drivers and passengers who both had a mean BAC of 0.15 g/100 mL.

The high mean BAC level among pedestrians in this study is a major concern, especially considering that as discussed previously, pedestrians made up the majority of RTA victims (Figure 2.1). In South Africa, the National Road Traffic Act 92 of 1996 governs the use of alcohol by drivers, however, no laws or interventions exist explicitly governing the use of alcohol by pedestrians. It is evident from these findings that to reduce the risk of pedestrians to RTAs, more needs to be done to limit drunk pedestrians.

The findings in this study show that alcohol consumption by these different road user groups, especially by pedestrians and drivers is a major problem. The legal BAC in South

Africa for driving was reduced in 1996 from 0.08 g/100 mL to 0.05 g/100 mL and 0.02 g/100 mL for professional drivers. Since this reduction there has not been a huge improvement in the number of alcohol-related RTA fatalities [41]. Further reduction of the legal limit might not the solution to reducing RTA related deaths [42]. Instead there might be a need for the establishment of alcohol-related preventative mechanism targeted at specific road users and perhaps stricter enforcement of blood alcohol laws and penalties for non-compliance with the relevant laws in South Africa [42]. In addition to this, there is a need for the implementation of education programs focused on increasing awareness on road safety.

2.4.6.2 Drug intoxication

Similar to alcohol, previous research has shown that there is an association between the use of psychoactive substances and an increased risk of RTAs [43-45]. However, a clear concentration-effect-relationship between the parent drug (and its metabolites), RTA risk and the severity of injury has to date not been established [46]. Unfortunately, relatively few regions routinely conduct investigations to determine the presence of psychoactive drugs in victims of RTA's. Studies which have been conducted revealed the prevalence of cannabis (3.5-27%), cocaine (33%), amphetamine (4.6-14%), opioids (19%) and benzodiazepines (3-12%) in drivers involved in RTAs [47-52]. The presence of antihistamines (2%), sedative cough suppressant (0.7%), mitragynine (0.9%) and

morphine (0.1%) have also been detected in drivers [53]. There are, however, limited studies on the detection of psychoactive drugs in other road users.

In South Africa, specimens for toxicological analysis (other than alcohol) are not routinely collected. Therefore, the presence of psychoactive substances could not be investigated in this study. Over the two-year period of this study, samples for drug analysis were only collected from 12 (2.10%) cases and results for these cases were not yet available. The epidemiology of drug abuse in South Africa has been studied previously [54, 55]. However, there is a limited number of studies investigating drugs in the context of RTAs. The role of drugs in RTAs is underestimated and it is important that drug analysis in such cases be made mandatory to fully appreciate their involvement.

2.4.7 RTA associated injuries

Investigating RTA associated injuries can assist in predicting the pattern of injuries obtained by RTA victims. The information produced by such studies can be used by medical services to reduce mortality rates by decreasing the diagnosis time and subsequent patient management [23]. This information can also be used by policymakers to make improvements to emergency services [23, 56]. In addition to this, analysing injuries obtained in RTAs is a useful way of assessing if current road safety mechanisms are working and what can be done to improve them [23]. With regards to forensic investigations, understanding RTA associated injuries can assist pathologists, law enforcement and the court in reconstructing the circumstances surrounding the RTA.

In this study, injuries were divided into two main categories: external and internal injuries. Internal injuries were further subdivided into those affecting hard tissue (e.g. bone fractures) and visceral injuries. Pedestrians were found to have the highest percentage of all these injuries, followed by drivers and passengers (Table 2.2). However, it is important to note that 58% of autopsied cases involved pedestrians (Figure 2.1). The distribution of injuries is similar to the distribution of road users. No significant difference was observed between the proportion of road users and the presence of external ($p = 0.089$), hard tissue ($p = 0.567$) and visceral ($p = 0.736$) injuries as a result of RTA. Similarly, there is also no significant difference in the number of external, hard tissue and visceral injuries ($p = 0.77$).

Table 2.2 | Distribution of type of injury per road user

Road User	Distribution of road user (%)	Injury *n* (%)		
		External	Hard	Visceral
Cyclist	1.63	9 (1.61)	8 (1.47)	9 (1.58)
Driver	17.24	98 (17.56)	95 (17.46)	100 (17.61)
Motorcyclist	8.29	47 (8.42)	45 (8.27)	47 (8.27)
Passenger	14.63	79 (14.16)	83 (15.26)	85 (14.96)
Pedestrian	58.21	325 (58.24)	313 (57.54)	327 (57.57)
Total	100	558	544	568

2.4.7.1 Region of injury

Figure 2.6 demonstrates the distribution of injuries according to the region of injury. Overall, most external injuries were observed on the face (70.19%), followed by lower (65.25%) and upper (64.05%) extremities. Pedestrians were more likely to suffer external injuries to the head (0.023), neck (0.032) and back (0.021). Motor vehicle occupants (driver/passenger) exhibited external injuries to the neck (41.98%), followed by upper extremities (31.91%) and the chest (31.13%).

The head (hard tissue: 43.69%; visceral: 40.78%) and the chest (hard tissue: 77.55%; visceral: 68.54%) were the most common regions affected by hard tissue and visceral injuries in this current study. Pedestrians were at greater risk of obtaining hard tissue injuries to the lower extremities. It is evident, that pedestrians are the most vulnerable road user, with minimum to little protection against RTAs. There is a need for preventative and protective mechanisms specifically tailored to protect this type of road user from RTAs.

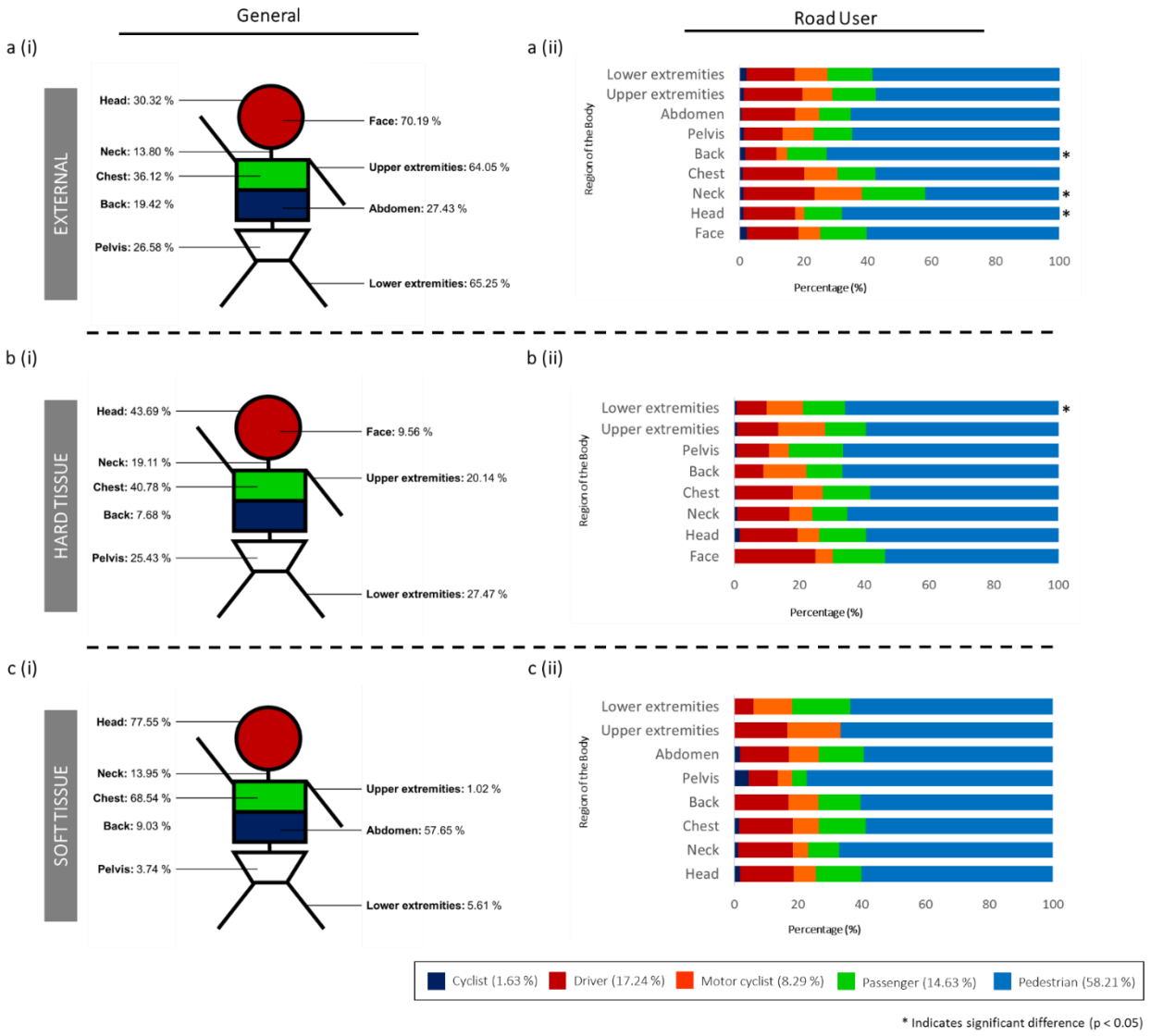

Figure 2.6 | Percentage distribution of RTA associated injuries according to body regions

2.4.7.2 External injuries

In this study, abrasions (66.51%) were the most common type of external injury followed by lacerations (22.23%) and contusions (11.27%) (Table 2.3). Abrasions contributed to the highest percentage of external injuries in all road users in this study (Figure 2.7). Abrasions are typically noted as the most common form of external injury in RTAs [23, 57, 58]. However, a study conducted in India on the injuries sustained by motor vehicle occupants noted, where lacerations were the most common type of external injury (38.28%), followed by abrasions (38.15%), and contusions (19.20%) [59].

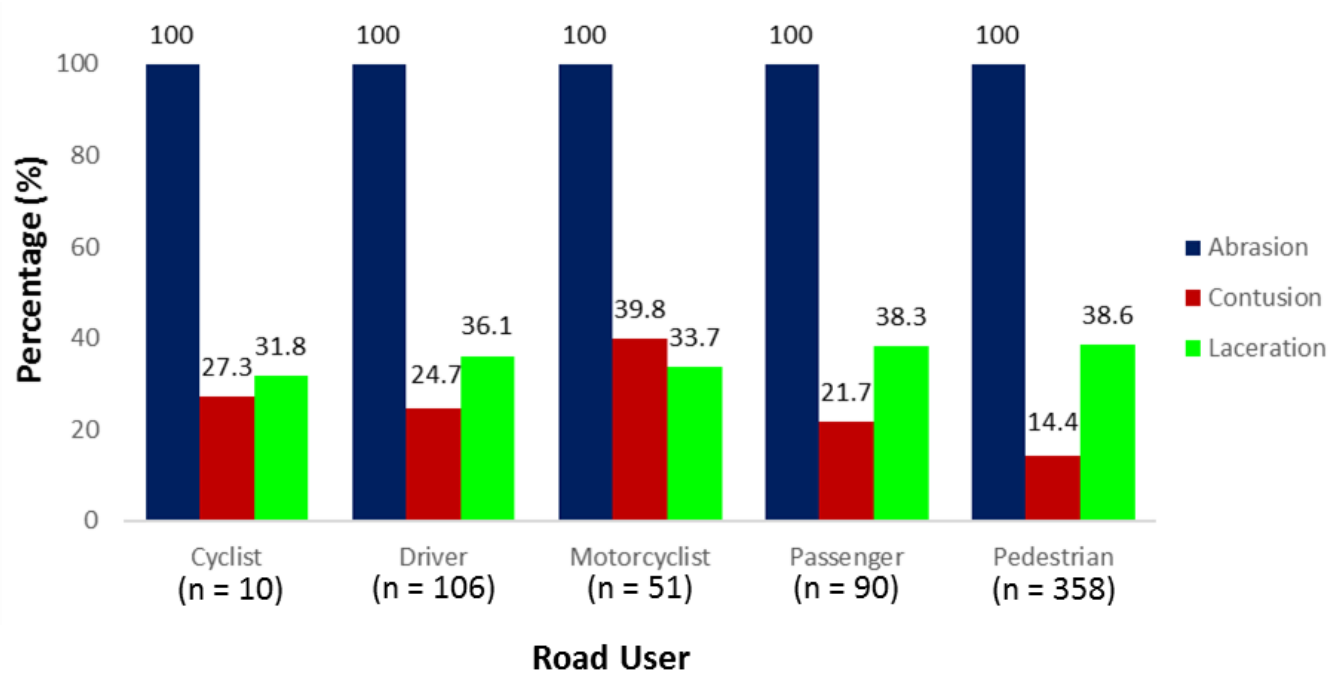

Figure 2.7 | Mean percentage distribution of external injuries according to road user

Table 2.3 | Distribution of external injuries in RTA victims over different regions of the body

REGION OF BODY	Abrasion (n)	Contusion (n)	Laceration (n)	Total n (%)
Face	349	72	184	605 (26.32)
Head	119	10	63	192 (8.35)
Neck	62	10	10	82 (3.57)
Chest	164	30	9	203 (8.83)
Back	99	1	3	103 (4.48)
Pelvis	112	9	27	148 (6.44)
Abdomen	131	16	13	160 (7.00)
Upper extremities	227	49	100	376 (16.35)
Lower extremities	266	62	102	430 (18.70)
Total	1 529	259	511	2 299 (100)

Degloving injuries are characterized by avulsion or detachment of subcutaneous tissue from underlying muscle and tissue [60], RTAs have been reported to be the most common cause of degloving injuries, frequently involving the lower extremities [61-63]. In this study degloving injuries were the most common injury observed to the upper (71.43%) and lower (53.85%) extremities. Degloving injuries have been reported to be common in pedestrians [64]. In the current study, no significant difference was observed ($p = 0.287$)

between degloving injuries to the lower extremities of pedestrians and motor vehicle occupants. For upper extremities, the was insufficient data to determine which road user was at greater risk of obtaining degloving injuries.

2.4.7.3 Hard tissue injuries

The distribution of hard and visceral tissue injuries is summarised in Table 2.4. Hard tissue injuries of the skull occurred in 53.25% of cases. These injuries consisted of various fractures (96.25%), followed by suture diastasis (3.54%). In a study conducted by Soni *et al.* [65] and Menon & Nagesh [66], linear fractures were the most common head fractures amongst victims of RTA. However, a review of head fractures in the current study, showed that comminuted fractures (75%) were the most common type of fracture. This is consistent with a study conducted in Fiji where comminuted fractures were also the most common type of head fracture [67]. Pedestrians had the highest percentage of fractures to the head (59.61%), followed by drivers (18.56%) and passengers (13.54%). The cause of pedestrians' increased head injury has been attributed to impact with the windscreen or impact to the A-pillar region of the car [68].

The neck is another commonly injured region in RTAs. Hard tissue injuries to the neck were observed in 19.11% of cases. These injuries consisted of dislocations (49.17%) and fractures (50.83%). The majority of dislocations and fractures were observed on the atlanto-occipital joint (64.5%) and the majority of fractures were observed on the cervical

vertebrae (83.6%). Typically, atlanto-occipital dislocation accounts for less than 1% of all cervical spine injuries, however, in RTAs, it is the most commonly noted cervical spine injury, with a prevalence as high as 35% [69]. Partial dislocations (75%) and fracture dislocations (63.16%) were commonly present in the current study. Pedestrians had the highest percentage of dislocations (64.5%) and fractures (60.66%), followed by drivers

Hard tissue injuries to the thoracic region were observed in 40.78% of cases. These injuries were in the form of fractures (94.91%), with relatively few dislocations (5.09%). The chances of obtaining fractures in this region of the body were significantly greater in pedestrians than in motor vehicle occupants (drivers and passengers) (P = 0.001). Most of the fractures involved the ribs (60.53%), followed by the vertebral column (13.56%) and the clavicle (12.35%) respectively. In a previous study, rib fractures (63.3%) were also the most common injury observed in the thorax [70]. A total of 54.85 % of rib fractures were observed in pedestrians followed by drivers (17.76%) and passengers (16.39%). The frequency of rib fractures in RTA victims is important because it can be a good indicator of underlying visceral injuries to the thorax [70].

Table 2.4 | Relative distribution of hard tissue and visceral tissue injuries in RTA victims over different regions of the body

	CYCLIST	DRIVER	MOTORCYCLIST	PASSENGER	PEDESTRIAN	p-value*
CASES	10 (1.63 %)	106 (17.24 %)	51 (8.29 %)	90 (14.63 %)	358 (58.21 %)	
HARD TISSUE INJURIES						
HEAD	7 (1.49 %)	85 (18.05 %)	33 (7.01 %)	64 (13.59 %)	282 (59.87 %)	0.782
NECK	1 (0.83 %)	20 (16.53 %)	8 (6.61 %)	13 (10.74 %)	79 (65.29 %)	0.522
THORAX	7 (1.42 %)	80 (16.19 %)	47 (9.51 %)	72 (14.57 %)	288 (58.30 %)	0.854
Clavicle	2 (3.28 %)	8 (13.11 %)	1 (1.64 %)	6 (9.84 %)	44 (72.13%)	0.097
Ribs	4 (1.38 %)	53 (17.73 %)	29 (9.36 %)	49 (16.39 %)	164 (54.85 %)	0.713
Sternum	1 (1.85 %)	11 (20.37 %)	8 (14.81 %)	10 (18.52 %)	24 (44.44 %)	0.248
UPPER EXTREMITIES	1 (0.62 %)	21 (12.96 %)	26 (16.05 %)	21 (12.96 %)	93 (57.41 %)	0.006
Humerus	1 (1.25 %)	9 (11.25 %)	4 (5.00 %)	12 (15.00 %)	54 (67.5 %)	0.410
Radius	0 (0.00 %)	6 (14.63 %)	11 (26.83 %)	4 (9.76 %)	20 (48.78 %)	0.001
Ulnar	0 (0.00 %)	6 (13.63 %)	11 (25.00 %)	5 (11.36 %)	22 (50.00 %)	0.002
PELVIS	1 (0.45 %)	21 (9.46 %)	12 (5.41 %)	28 (12.61 %)	160 (72.07 %)	0.001
LOWER EXTREMITIES	1 (0.36 %)	26 (9.32 %)	30 (10.75 %)	38 (13.62 %)	184 (65.95 %)	0.001
Femur	0 (0.00 %)	9 (10.84 %)	11 (13.25 %)	18 (21.69 %)	45 (54.22 %)	0.065
Fibula	1 (1.09 %)	8 (8.70 %)	10 (10.87 %)	10 (10.87 %)	63 (68.48 %)	0.118
Tibia	0 (0.00 %)	9 (8.65 %)	9 (8.65 %)	10 (9.62 %)	76 (73.08 %)	0.118
VISCERAL INJURIES						
BRAIN	27 (1.93 %)	235 (16.79 %)	96 (6.86 %)	189 (13.5 %)	853 (60.93 %)	0.116
THORAX	15 (1.50 %)	170 (17.03 %)	85 (8.52 %)	142 (14.23 %)	586 (58.72 %)	0.987
Heart	6 (2.40 %)	43 (17.20 %)	21 (8.40 %)	30 (12 %)	150 (60.00 %)	0.693
Lungs	2 (0.63 %)	56 (17.72 %)	28 (8.86 %)	47 (14.87 %)	183 (57.91 %)	0.715
Spinal cord	0 (0.00%)	13 (20.00 %)	8 (12.31 %)	4 (6.15 %)	40 (61.54 %)	0.205
ABDOMEN	17 (1.94 %)	132 (15.05 %)	76 (8.67 %)	151 (17.22 %)	501 (57.13 %)	0.121
Kidneys	2 (1.46 %)	19 (13.87 %)	9 (6.57 %)	27 (19.71 %)	80 (58.39 %)	0.429
Liver	5 (1.97 %)	43 (16.93 %)	22 (8.66 %)	42 (16.54 %)	142 (55.91 %)	0.895
Spleen	3 (2.86 %)	15 (14.29 %)	13 (12.38 %)	19 (18.10 %)	55 (52.38 %)	0.278
BLOOD VESSELS	0 (0.00 %)	33 (18.86 %)	14 (9.14 %)	26 (14.86 %)	100 (57.14 %)	0.507
Aorta	0 (0.00 %)	7 (30.43 %)	0 (0.00 %)	0 (0.00 %)	16 (69.57 %)	0.076
Ascending aorta	0 (0.00 %)	3 (12.5 %)	1 (4.17 %)	6 (25.00 %)	14 (58.33 %)	0.564
Descending thoracic aorta	0 (0.00 %)	18 (19.35 %)	10 (10.75 %)	17 (18.28 %)	48 (51.61 %)	0.409

*p-value denotes significance of the distribution of injuries according to road user compared to relative case numbers for each road use

Sternal fractures are a rare injury, however, the incidence of sternal fractures in RTAs has increased over time. A study conducted over a three-year (1991 – 1993) period showed that the incidence of sternal fractures in RTAs increased from 0.7% to 4% [71]. Studies have associated this increase with increased utilisation of seatbelts [71-74]. In the present study, sternal fractures occurred in 11% of RTA victims. Pedestrians had the highest percentage of sternal fractures (44.44%), followed by drivers (20.37%) and passengers (18.52%). No significant difference was observed between the number of sternal fractures obtained and road users ($p = 0.248$). With regards to motor vehicle occupants, information on how many were wearing seatbelts at the time of the RTA was lacking. Thus, the association between sternal fractures and seat belt usage could not be established.

A study conducted by Ooi *et al.* [75] showed that RTAs (52%) were the most common mechanism of injury for pelvic fractures. To date in South Africa, there is poor documentation of RTA associated injuries. This is unfortunate, considering that pelvic fractures are a major cause of death and disability in RTAs [76]. Previous studies [37, 77] have reported that approximately 25% of RTA victims sustain injuries to the pelvis. In the current study, hard tissue injuries to the pelvis occurred in 25.43% of cases. The most common injury to this region was fractures (72.20%), followed by diastasis (21.52 %) and dislocation (5.83%). Pedestrians had the highest percentage of pelvic fractures (71.97%), followed by passengers (14.65%) and drivers (9.55%). No significant difference ($p = 0.653$) between the number of drivers and the number of passengers that had pelvic fractures was observed. This finding was also noted by Daffner *et al.* [78]. However, when

compared to motor vehicle occupants, pedestrians had a significantly greater chance ($p = 0.0012$) of sustaining fractures to the pelvis. This is because pedestrians are the least protected road user. As a result, they receive the full impact of the kinetic energy transfer during a motor vehicle collision, resulting in severe injuries to the pelvic region [75]. Open book fractures accounted for 42.3% of pelvic fractures. This was followed by non-displaced fractures (23.08%) and comminuted fractures (19.23%). Spitz & Fischer [79] also reported that open book fractures were the most common type of pelvic fracture. However, in the current study all open book fractures were sustained by pedestrians, compared to previous where motor vehicle occupants who were in close proximity to the steering wheel (drivers) and the dashboard (front seat passengers).

Hard tissue injuries to the upper extremities were observed in 20.14% of cases. Fractures were the only hard tissue injury observed. The most common type of fracture was closed (54.72%), followed by compound (26.42%) and comminuted (11.32%). A previous study conducted in India showed that humeral fractures accounted for the greatest percentage of injuries to the upper extremities (31.25%), followed by fractures to the ulnar (15.63%) and radius (12.5%) [70]. In the current study, humeral fractures (48.48%) were also the most common injury to the upper extremities, followed by fractures of the ulnar (26.67%) and radius (24.85%). Pedestrians had the highest percentage of fractures to the upper extremities (57.4%), followed by motorcyclists (16.05%) and motor vehicle occupants (drivers: 12.96%; passenger: 12.98%). A study investigating upper extremity fractures to pedestrians revealed that humeral fractures were observed in 11% of the cases followed by fractures to the ulnar (7%) and radius (6%) [80]. In the current study, humeral fractures

were more prevalent amongst pedestrians. Fractures of the humerus were observed in 67.5% of pedestrians. Fractures of the ulna and radius were noted in 50% and 48.8% of pedestrian cases, respectively. When compared to motor vehicle occupants, pedestrians had a greater chance of sustaining fractures to the upper extremities ($p = 0.001$) and of sustaining humeral fractures ($p = 0.038$). No significant difference was observed in the number of fractures of the radius ($p = 1.0$) or ulnar ($p = 1.0$) between drivers and passengers.

Lower extremity injuries have been described as the most frequent type of injury in RTAs. In the current study, injuries to the lower extremities were observed in 27.47% of cases. The majority of these injuries were fractures (99.64%). There was only a single case where a dislocation was observed. Most of the fractures observed were closed (61 %), followed by compound (33.60%) and comminuted (12.8%) fractures. The greatest percentage of lower limb fractures were sustained by pedestrians (70%), followed by passengers (13.72%) and motorcyclists (10.83%). A study investigating RTA associated injuries in motor vehicle occupants showed that fractures to the lower extremities were the most common in drivers and front seat passengers [81]. However, previous studies have shown that injuries to the lower extremities are more common in pedestrians than in motor vehicle occupants [82-84]. The findings in this study have also shown that the chances of obtaining injuries to the lower extremities are significantly greater in pedestrians than in motor vehicle occupants ($P \leq 0.001$).

Previous analysis of lower limb injuries associated with RTAs showed that femoral fractures were the most frequent injury accounting for 18.6% of injuries to the lower extremities [85]. In a South African based study investigating RTA associated orthopaedic injuries in children, femoral fractures made up the majority of fractures (35.4%) [86]. Another study showed that fractures to the femur accounted for the highest percentage (31.99%) of fractures in motor vehicle occupants, more so in drivers than passengers [87]. It was, therefore, expected that in the current study the femur would have the greatest percentage of injuries. However, fractures of the tibia (37.28%), were the most frequent injury to the lower extremities, followed by fractures to the fibula (32.97%) and the femur (29.75%). Similar observations were made by Landy *et al.* [80] where the tibia and fibula accounted for 44 % of injuries followed by femoral fractures (13%). When compared to drivers, passengers had the greatest chance of obtaining injuries to the femur ($p = 0.006$), fibula ($p = 0.0018$) and tibia ($p = 0.003$). However, pedestrians had the greatest risk of obtaining fractures to the femur ($p = 0.0016$), fibula ($p = 0.0045$) and tibia ($p = 0.0008$).

2.4.7.4 Head and spinal tissue injuries

Head injuries have been reported to be very common in RTAs [88]. In a study conducted by Yattoo & Tabish [89], RTAs were the main cause of head injuries accounting for 44.44% of the cases. In another study [90], investigating head trauma in children, RTAs (58.3%) were reported to be the main cause of head trauma. Emejulu & Malomo [91] also reported that a great percentage of head trauma resulted from RTAs (67.5 %). Farooqui

et al. [23] attributes this increased percentage of RTA associated head trauma to the lack of helmet use by two-wheel users and the lack of seatbelt use by motor vehicle occupants. Emejulu & Malomo [91] argues that the poor state of roads and poor compliance with traffic regulations is the reason for increases in RTA associated head trauma.

In the current study, injuries to the head were observed in 77.55% of the cases. These injuries were observed on the brain (75.57%). In a previous study [23], the brain was reported as the most frequently injured organ. In this present study, pedestrians had a greater chance of sustaining injuries to the brain ($p = 0.001$) than motor vehicle occupants. Similar findings were found by Toro *et al.* [37], who reported that pedestrians and cyclists were more likely to obtain RTA associated head injuries. Kraus *et al.* [92] contradicts these findings by reporting that the majority of head injuries (62%) were observed in motor vehicle occupants.

In the current study, intracranial injuries were predominantly made up of haemorrhages (50.4%), followed by lacerations (13.14%), and contusions (9.83% of the brain). Subarachnoid haemorrhages were most commonly reported (75.9%) followed by subdural haemorrhages (42.41%). In the current study, pedestrians had the highest percentage of haemorrhages (63.79%), followed by drivers (14.95%) and passengers (12.48%). The findings in this study showed that the chances of obtaining haemorrhages was significantly greater in pedestrians than in drivers ($p = 0.001$) and passengers ($p = 0.001$).

injuries to the neck were observed in 13.95% of the cases. These injuries were predominantly haemorrhages (69.18%) and transections (19.86%). Visceral haemorrhages made up 87.23% of the haemorrhages. All the transections were complete transections of the spinal cord. Pedestrians had the highest percentage of haemorrhages (57.43%) and transections (62.07%), followed by drivers (haemorrhages: 18.81%; transections: 20.69%) and passengers (haemorrhages: 13.86%; transections: 13.79%). When compared to motor vehicle occupants, pedestrians had a greater chance of obtaining injuries to the neck ($p = 0.001$). In addition to this, pedestrians had a greater chance of obtaining haemorrhages ($p = 0.0189$) and transections ($p = 0.001$) than motor vehicle occupants.

Injuries to the back were observed in 9.03% of cases. These injuries involved the spinal cord (84.42%) and the spinal column (15.58%). Pedestrians had the greatest percentage of injuries to the spinal column (41.67%), followed by drivers (25%) and passengers (25%). Pedestrians also had the highest percentage of injuries to the spinal cord (61.54 %), followed by drivers (20%) and motorcyclists (12.30%). No significant difference was observed between the injuries to the spinal column ($p = 0.2612$) and spinal cord ($p = 0.17$) of pedestrians and motor vehicle occupants. Visceral injuries to the back were made up of transections of the spinal column and or spinal cord (33.77%) and haemorrhages (33.77%), followed by lacerations (20.78%). Pedestrians had a significantly greater chance of obtaining transections ($p = 0.0187$) and haemorrhages ($p = 0.0016$) to the back than motor vehicle occupants.

2.4.7.5 Visceral injuries

Visceral injuries to the thoracic region were observed in 68.54% of the cases. The majority of these injuries were in the form of haemorrhages (30.46%) and contusions (22.02%). Hemothoracies were noted in 21.03% of cases. Most of the injuries to the thoracic region were observed on the lungs (31.66%) and the heart (25.05%). Pedestrians had a greater chance of obtaining injuries to the lungs ($p = 0.001$) and heart ($p = 0.001$) than motor vehicle occupants. A previous study [70], investigating the pattern of thoraco-abdominal injuries in fatal RTAs, reported that the lungs (92.3%) were the most frequently injured organs in the thoracic region, mostly exhibiting lacerations (79.1%). In contradiction to this, the current study mostly observed contusion (70.72 %), followed by laceration (44.21%) and haemorrhage (17.97%) of the lungs.

In the current study, injuries to blood vessels were observed in 19.02% of cases. Similar observations were made in another SA based study, where 20.5% of RTA victims sustained injuries to blood vessels [88]. Previous studies have reported that injury to the aorta is the second most common cause of death in RTAs [88]. In the current study, it was found that the aorta was the most injured blood vessel (86.29%), followed by the inferior vena cava (6.29%). The region of the aorta that was mostly affected was the descending thoracic aorta (61.59%), followed by the ascending aorta (15.89%). The descending thoracic aorta was also reported to have sustained the most injuries in a previous study (11.8%), although no injuries to the ascending aorta were observed [88].

Injuries to blood vessels were predominantly in the form of lacerations (50.29%), followed by transections (24.86%) and haemorrhages (12.72%). Of the lacerations described, 64.28% were transverse lacerations and 28.57% were described as step ladder lacerations. The majority of these lacerations (82.75%) were observed on various regions of the aorta. Lacerations of the aorta were described by Prahlow [93] as a “classic” injury in RTA victims. In the current study, 88.37% of the transections to blood vessels were observed on the aorta. Pedestrians had an increased chance of obtaining injuries to the aorta ($p = 0.001$) and haemorrhages ($p = 0.0056$) than motor vehicle occupants.

Blunt force trauma injuries to the abdomen are seen in 2-5% of all accidents, accounting for 51.6% of fatal accidents [94]. A study conducted in India argued that RTAs are the most common mechanism of injury for blunt force abdominal injuries. In the current study, visceral injuries to the abdomen were observed in 57.89% of cases. These injuries were predominantly made up of lacerations (41.44%), and haemorrhages (22.72%). A consequence of these injuries was hemoperitoneum, which was observed in 10.50% of the cases. A previous study [8] reported that the spleen (46.8%) was the most common organ injured, followed by the intestines (19.4%) and the liver (16.1%). The current study found the liver to be the most commonly injured abdominal organ (28.96%), followed by kidneys (15.62%). Pedestrians were at a great risk of obtaining blunt force injuries to the liver ($p = 0.001$) and kidneys ($p = 0.001$) than motor vehicle occupants. Compared to other regions of the body, the abdomen is susceptible to injuries because these regions of the body have minimal bony protection for underlying organs.

2.5 LIMITATION

A limitation of this study is that the data collected was obtained from autopsy files and a database that was not compiled by the author. As a result, assumptions were made about some of the injuries described in this manuscript, as pathologists often use different nomenclature to describe the injuries they observed. Another limitation of this study is that it only includes RTAs with a fatal outcome. The exclusion of non-fatal RTAs is a limitation because it does not provide insight into RTA associated injuries obtained by RTA survivors and therefore limits our appreciation of RTA associated injuries as a whole.

2.6 CONCLUSION

Research investigating various aspects of RTAs has been conducted in South Africa. However, studies investigating RTA associated blunt force trauma injuries are limited. In the West Metropole region of Cape Town (South Africa), during the two-year period (1 January 2013 to 31 December 2014), pedestrians were the most vulnerable road user, followed by drivers, passengers, motorcyclists and cyclists.

Abrasions contributed to the highest percentage of external injuries in all road users. This was followed by lacerations and contusions for all road users, except motorcyclists, where the opposite was found, Pedestrians had the highest percentage of head, rib, pelvic, upper extremity and lower extremity fractures. Fractures to these regions were also observed in motor vehicle occupants (drivers and passengers). There was a high incidence of visceral injuries to the brain, where the most common intracranial injuries (haemorrhages, lacerations and contusions) were observed in pedestrians, followed by motor vehicle occupants.

Further studies investigating the relationship between severity of injury, pre-, during and post hospitalisation need to be conducted as these factors have a huge influence on the survival rates of RTA victims. Improvements in these areas may result in a decrease in RTA fatalities. In addition to this, this information can also be used to direct research towards other areas in RTAs that need further investigations. Research like this is very

important because it can be used by various organisations to inform educational programs and develop preventive mechanisms that can increase the safety of all road users.

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CHAPTER THREE:
Appendices

Appendix A: Acknowledgments

Prima facea, I would like to thank God for providing me with the strength, I needed to complete this thesis. I would like to express my sincere gratitude to my supervisor, Calvin Mole for his continuous support, guidance, and patience throughout the research and writing process. He had an open-door policy and was always available to answer questions and provide assistance. Finally, I would like to thank my mother, Patricia. D. Majero for supporting me spiritually and encouraging me throughout the writing process.

Appendix B: Ethics approval letter

The letter was removed to avoid exposing the authority's signature.

Appendix C: Estimated population data for the West Metropole region of Cape Town (South Africa).

The estimated population data for the individual suburbs for the west metropole region of Cape Town were obtained from the 2011 Census, which is available here: http://www.capetown.gov.za/Family%20and%20home/education-and-research-materials/data-statistics-and-research/cape-town-census

Suburb	Population	Suburb	Population
Acacia Park 817	817	Green Point	9 301
Athlone	45 048	Gugulethu	98 468
Atlantis Non-Urban	2 479	Hanover Park	45 497
Atlantis	67 491	Hazendal	4 995
Bergvliet	4 428	Heathfield	7 226
Bishopscourt	1 603	Heideveld	21 288
Bloubergstrand	11 179	Hout Bay	17 329
Bonteheuvel	52956	Imizamo Yethu	15 538
Bothasig	11790	Joe Slovo Park	12 629
Brooklyn	10941	Kalk Bay	700
Camps Bay	4982	Kennilworth	10 872
Cape Peninsula National Park	286	Kensington	24 161
Cape Town CBD	5647	Kirstenhof	4 515
Capri	3061	Kleine Zout Rivier Small Holdings	283
Capricorn	4 458	Knole Park	2 961
Castle Rock	5 595	Kommetjie	3 341
Century City	4 239	Lakeside	3 801
Claremont	17 198	Langa	52 401
Clifton	507	Lansdowne	18 650
Clovelly	559	Lavenderhill	32 598
Coniston Park	1 833	Llandudno	571
Constantia	12 454	Lotus River	38 143
Crossroads	36 043	Maitland Garden Village	1 834
Da Gama Park	2 346	Maitland	9 782
Diep River	2 515	Mamre	9 048
Dreyersdal	2 130	Manenberg	61 615
Edgemead	9 884	Marconi Beam	37
Epping Industria	50	Marina da Gama	3 390
Fairways	2 952	Masiphumelele	21 904
Fish Hoek	9 052	Meadowridge	3 194
Foreshore	762	Melkbosstrand	11 303
Gardens	7 960	Milnerton Non-Urban	3 293
Glencairn	1 574	Milnerton	14 306
Grassy Park	19 212	Mitchells Plain	310 485

Suburb	Population	Suburb	Population
Montague Gardens	22	Sea Point	16 164
Monte Vista	7 023	Sheraton Park	3 111
Mowbray	4 726	Silvertown	27 146
Muizenberg	5 537	Simons Town	2 649
Ndabeni	1 014	Southfield	7 106
Newlands	5 100	St James	4 91
Noordhoek	4 424	Steenberg Estate	796
Nyanga	57 996	Steenberg	4 168
Observatory	9 207	Stonehurst Mountain Estate	678
Ocean View	13 569	Summer Greens	6 275
Oranjezicht	3 580	Sun Valley	4 869
Ottery	17 942	Sunningdale	5 299
Oude Molen Village	530	Sybrand Park	1 613
Paarden Eiland	11	Table Mountain Nature Reserve	114
Parklands	24 614	Table View	25 977
Parkwood	11 870	Tamboerskloof	2 984
Pelikan Park	12 552	Thornton	5 862
Pella	1 681	Tijgerhof/Sanddrift	6 178
Philippi	191 025	Tokai	3 664
Philippi Small Holdings	6 618	University of Cape Town	471
Phoenix	4 219	V & A Waterfront	1 570
Pinelands	14 198	Vissershok	323
Plumstead	20 178	Vredehoek	5 415
Pollsmoor	2 161	Vrygrond	18 498
Red Hill	1 016	Westlake	6 452
Retreat	35 709	Wingfield	3 129
Robben Island	116	Woodstock	12 656
Rondebosch/Rosebank	19 554	Wynberg	14 472
Rugby	4 431	Youngsfield	887
Ruyterwacht	10 773	Ysterplaat Airbase	838
Salt River	6 577	Zeekoei Vlei	421
Scarborough	1 075	Zonnebloem	5 122
Schotschekloof	3 203	**Estimated population total**	**1 937 139**

Appendix D: Instructions to Authors

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FORENSIC SCIENCE INTERNATIONAL

An international journal dedicated to the applications of medicine and science in the administration of justice.

AUTHOR INFORMATION PACK

DESCRIPTION

Forensic Science International publishes original contributions in the many different scientific disciplines pertaining to the forensic sciences. Fields include forensic pathology and histochemistry, chemistry, biochemistry and toxicology (including drugs, alcohol, etc.), biology (including the identification of hairs and fibres), serology, odontology, psychiatry, anthropology, the physical sciences, firearms, and document examination, as well as investigations of value to public health in its broadest sense, and the important marginal area where science and medicine interact with the law.

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Types of paper

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2. Review Articles
3. Rapid Communications
4. Technical Notes
5. Forensic Anthropology Population Data
6. Case Reports
7. Preliminary Communications
8. 8.Letters to the Editor

9. Book Reviews

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- Aging sub adult skeletal remains
- Aging adult skeletal remains
- Aging living sub adults and adults
- Determining ancestry
- Stature estimation
- Facial reconstruction
- Non metric trait distribution, pathology and trauma
- Positive identification of human skeletal remains
- Positive identification of the living

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Fax:+34 981 580336
E-mail: angel.carrafsi@usc.es

P. Margot: Questioned Documents and Physical Science: ballistics, tool marks, contact traces, drugs analysis, fingerprints and identification, etc.
Tel: +41 21 692 4605
Fax: +41 21 692 4605
E-mail: pierre.margot@unil.ch

O.H. Drummer: Toxicology
Tel: +61 3 9684 4334

Fax: +61 3 9682 7353
E-mail: olaf.drummer@vifm.org

S. Matuszewski: Entomology
Tel: +48 61 82 94 292
E-Mail: szymmat@amu.edu.pl

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[2] W. Strunk Jr., E.B. White, The Elements of Style, fourth ed., Longman, New York, 2000.
Reference to a chapter in an edited book:

[3] G.R. Mettam, L.B. Adams, How to prepare an electronic version of your article, in: B.S. Jones, R.Z. Smith (Eds.), Introduction to the Electronic Age, E-Publishing Inc., New York, 2009, pp. 281–304.
Reference to a website:
[4] Cancer Research UK, Cancer statistics reports for the UK. http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/, 2003 (accessed 13 March 2003).
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